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CALIFORNIA'S CITRUS-FRUIT INDUSTRY—YOUNG TREES IN THE NURSERY READY FOR TRANSFER TO THE OPEN GROUND
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THE SEQUEL

THE story of how this Government when faced with the emergency of war awoke to the fact that the conflict was primarily one of engineering, how when seeking the aid of American engineering talent no general organization of engineers was to be found, how in this crisis four great engineering societies banded together to form the Engineering Council through which they could furnish united assistance to the Government and what a vital part in the mighty conflict was played by American engineers—all this is now an old and familiar story, but it has a sequel which has not yet been written; in fact, it is only just being enacted.

The advantages of coöperative effort during the war were so clearly apparent as to point to the importance of continuing such united service in time of peace. In order to form an association that would be broader and more comprehensive than the Engineering Council and which would be representive of every branch of engineering, not merely in its national organizations but in its local sections as well, a conference was called in Washington on the 3rd and 4th of June last. This proved to be one of the most remarkable meetings of engineers ever held. One hundred and forty delegates attended, representing seventy-one engineering societies from all parts of this country. The unanimity displayed was remarkable. The war had given American engineers a new sense of power for public service, and the contrast between such service and the inefficient conduct of numberless public enterprises launched without adequate engineering advice was glaringly evident.

A second meeting is to be held in Washington on November 18 and 19 at which the organization of the Federated American Engineering Societies will be completed and plans will be formulated for taking over the work of the Engineering Council.

The engineering profession naturally divides itself into a large number of classifications which have been organized into separate societies, but heretofore they have been working independently and as a consequence the voice of the engineer has had little weight in national affairs.

The engineer is primarily an organizer and is constantly engaged in organization work; the wonder is that never before has any serious attempt been made to bring all the various branches of engineering together so that they could, when required, operate as a united whole. The benefits to the nation at large as well as to the individual engineer are so evident that we cannot but urge every engineering association in the country to enter into the Federation and thus preserve in time of peace a service that proved so valuable in time of war.

THE COST OF DARKNESS

THANKS to the efforts of the industrial engineer, the worker today is receiving careful and scientific study. In the war on waste in which every manufacturer should coöperate, unnecessary fatigue is a most important factor. Its cost in dollars and cents foots up to a most impressive total.

In order to focus attention upon this matter and stir the public to real action the Society of Industrial Engineers has designated the first Monday of December each year as Fatigue Elimination Day. On the sixth of next month, then, all manufacturers are invited to make a survey of their plants to discover sources of unnecessary fatigue and to take measures to eliminate these sources. The installation of chairs, the proper height of benches, the provision of arm rests and foot rests, the introduction of rest periods—these are some of the important matters to be considered.

Among the various angles of this subject is that of factory illumination. Insurance companies have already tabulated the number of accident due to inadequate lighting. In one report of 91,000 accidents ten per cent were due to poor lighting, and in 13.8 per cent of the accidents lack of proper illumination was a contributing cause.

It is very evident that a dark shop is full of pitfalls and concealed dangers, but we are apt to overlook the accidents that are indirectly attributable to poor lighting. When a normal man works, his eyes work too; they perform actual muscular labor. An arm may be fatigued without affecting the rest of the body, but eye fatigue reacts upon the whole human system, with the result that the work turned out is poorer in quality and reduced in quantity, while the general lowering of the worker's efficiency makes him less alert and more liable to accident.

The high cost of labor today makes it pay to invest in equipment that will better the efficiency of operatives even by a small percentage. Daylight must be let into the plant by substituting glass walls and roofs for the dingy brick walls and narrow, dirty windows that characterized the factory building of yesterday. The glass must be kept clean and the light, after it has been admitted, must be conserved by the use of dead white paint, not only on the walls, but even on the machines. Artificial light should be so disposed as to prevent glare and flicker. Eye strain may come from an overabundance as well as an insufficiency of light.

Proper illumination cannot be had without expense. A large automobile company informs us that the cost of a single washing of 300,000 square feet of windows and skylights in its plant foots up to six thousand dollars! But the sum is repaid many times over in the increased efficiency of the workers.

Height and Velocities of Meteors

Sources of the Dust and Debris Which Our Earth Encounters in Its Orbit

By W. F. Denning, F.R.A.S. Hon. Fellow R.A.S. of Canada, etc.

HAVING during the last 34 years (1886-1920) computed the real paths of 1,110 fireballs and shooting stars of which multiple observations were obtained, I have arrived at certain conclusions from a comparison and discussion of the results. One is that meteors never visibly take fire at a height of 100 miles above the earth's surface and it is probable that very few if any become luminous at an elevation of 90 miles. It is true that I have occasionally found heights exceeding 100 miles and that other students of this branch have obtained similarly high figures, but I believe, from a fair consideration of the evidence, that such deductions are unreliable and due to errors in recording the flights of these objects. Observers frequently catch the first glimpse of a meteor when it has already traversed a section of its path and then guess the actual starting point by putting the line of flight 5° or 10° or even 20° backward. This often induces errors of large extent and gives elevations which must exceed the true values.

Nearly all the most reliable of path records definitely indicate that meteors are less than 90 miles high at the beginning of their luminous flight. The very rapid meteors meeting the earth in the front of its orbital direction are rendered combustible at elevations between 85 and 75 miles and burnt out at 55 to 45 miles. These include Leonids, Perseids and showers of the same character.

The very slow meteors overtaking the earth and moving in the same direction, are first seen when from 65 to 55 miles high and are consumed after falling to between 50 and 25 miles, but much depends upon the situation of the radiant point relatively to the horizon. When the radiant is on, or very near, the horizon the swift meteors are about 70 miles high and the slow ones 54 miles. The latter when the radiant is pretty considerably elevated often fall to within 33 to 25 miles of the earth's surface.

The more rapid the flights the quicker are the objects consumed and the higher in the air incandescence is attained. It is only the slow or very slow moving meteors that are able to preserve their integrity and descend upon the earth in compact forms. No Leonids or Perseids, notwithstanding their abundance, have ever been known to alight on the terrestrial surface.

The apparent places of the radiant points have a material effect upon the lengths of meteor paths and often upon the velocity of the meteors. The latter when shooting from a zenithal radiant usually traverse short, diving courses of about 25 miles, while those from radiants closely bordering or on the horizon describe extensive paths of about 200 miles or more and their rate of velocity is decidedly less than the normal value owing probably to the effects of atmospheric resistance. The difference between meteors from zenithal and horizontal radiants may be contrasted by watching a shower like the Perseids or Leonids with their radiant just risen and again when they are near the meridian. I give a few examples of the discordances in such flights:

Date	*Radiant*		*Height* Began	Ended	*Path*	*Velocity*	
			Miles		*Miles*	*Miles*	
	Zenithal Radiants						
1917, Mar. 18	....110°	+53°	66	41	25	25	SS
1917, April 17	162	+58	52	41	11	11	SS
1914, May 17	219	+40	71	47	24	34	SS
1917, July 16	316	+48	62	48	14	35	SS
1915, Aug. 13	244	+72	59	29	30	30	F
1914, Aug. 17	281	+46	64	48	16	32	SS
1914, Aug. 29	293	+51	67	47	20	26	SS
1896, Nov. 14	150	+24	75	50	29	58	SS
	Horizontal Radiants						
1920, Feb. 4	......144°	+ 8°	55	46	275	20	F
1896, Mar. 1	 18	+ 5	55	55	405	20	SS
1900, May 3	337	+ 0	54	49	155	28	SS
1889, May 22	 63	+35	50	58	292	14	F
1899, June 2	250	—23	61	51	170	Slow	F
1913, June 14	282	—23	54	54	490	26	F
1919, Oct. 22	154	+39	72	72	335	33	F
1897, Nov. 14	150	+24	83	78	157	40	SS

Abbreviations: S.S. = Shooting Star. F. = Fireball.

These selections will sufficiently show the great difference observed in the length of the luminous courses.

In their aspects as they slide along the firmament and also in their real origin and characteristics meteors display so great a diversity that it must impress every observer who stands and watches their display. The theoretical velocities are from about 10 to 45 miles per second, but these are not always corroborated. There are some well substantiated cases where meteors have traveled with far greater or less speed than might have been expected. In certain accurately observed instances where duplicate records were obtained of identical objects, the actual velocity worked out at more than 100 miles per second. In one case where the late Prof. A. S. Herschel and the writer observed a meteor under very favorable circumstances the velocity proved to have been only 15½ miles per second, whereas the parabolic velocity would be 34 miles per second. The computation of several meteors of deficient velocity are here given for comparison.

Date	Radiant Point	Observed Velocity per sec. Miles	Computed Velocity per sec. Miles	Computer
1901 Aug. 10	351° —11°	18¾	30¼	A. S. Herschel
10 58	351½ —10½	16¼		G. L. Tupman
10 58	352 14	15		W. F. Denning
1901 Aug. 18	105+52	15	34	S. A. Herschel
h m	106+52	16¼		G. L. Tupman
13 24	106+52	15		W. F. Denning
1900 May 3	335 —1	25		
h m			40	A. S. Herschel
13 58	337 —0	28		W. F. Denning

In these cases the velocity was about one-half of that computed. The following include instances of excessive velocity:

Date	Radiant	Observed Velocity Miles	
1902 Sept. 25	254°+46°	100	
1902 Aug. 10	305 +54	100	
1914 July 22	332 +31	90	Computed by
1914 Aug. 12	280 +44	80	the
1895 Sept. 11	352 +30	92	writer at
1917 Oct. 6	10 +37	80	Bristol

The observation on which all these results depend were made by persons of experience in observing meteors and determining the durations of their flight.

Showers are sometimes seen indicating a velocity inconsistent with the position of radiation; thus on 1885, Sept. 3-8, I saw 19 very swift meteors from a radiant at 354° —38°.

Many theories have been advanced in explanation of the origin of meteors. Olbers concluded they were the fragments of a planet discovered by explosion. Clapp, Day and others

regarded them as terrestrial comets. Laplace and Hutton thought they emanated from lunar volcanoes. La Grange and Brewster favored the view that they had been originally expelled from volcanoes on the earth. Dr. Blagden held the view that they were electrical phenomena. Sir Isaac Newton had the idea that they proceeded from the tail of comets. Herrick wrote: "Millions of small planetary bodies of various magnitudes are revolving round the sun and when any of these dart into our atmosphere they become united and are seen in the form of shooting stars." Tschermak conjectured that they formed volcanic ejecta from some large celestial body. Sir Robert Ball thought them due to the action of terrestrial volcanoes in the distant past.

It appears to the writer that meteors have been too simply generalized as to their outcome and orbital constructions. Space within the known limits of the solar system is teeming with these stony and metallic particles and fresh streams of them are being introduced by the same planetary attraction which seems to have initiated the various comet families. Certain meteoric systems may have variously had their offcome from the earth, moon and other planets. Possibly also the sun and stars may have furnished a fruitful parentage—at any rate it seems a probable inference that the dust and debris of worlds or of comets which give rise to meteors had their origin in a variety of sources and activities. This appears evident by their diversity. Abnormally slow meteors may have been influenced by air resistance; but though much has already been accomplished by observation, the whole subject of meteoric astronomy requires far more thorough investigation than has hitherto been applied to it.

Glacial and Genial Epochs

An Astronomical Explanation of the Glacial Periods

By F. J. B. Cordeiro

An elastic sphere, subject to the gravitational attraction of another body is inevitably deformed into a prolate ellipsoid of revolution with its long axis pointing toward the attracting body. Our earth is an elastic body which subjected only to its own self-gravitation would assume the shape of a sphere. But, since it rotates about an axis, centrifugal forces of rotation are added which transform the sphere into an oblate ellipsoid of revolution, or spheroid. If now another body act upon it, such as the moon, the spheroid is still further deformed into an oval body which always keeps its long axis pointing toward the attracting body. That is, as the moon revolves about the earth, the distortion of the earth's shape which it produces is always fixed relatively to the moon, and a solid or body tide sweeps around the earth in the plane of the moon's orbit, having the same period as the moon. Now the effect of this body tide is evidently to bring the earth to a condition where there will be no relative motion between earth and moon and such will be the final condition.

Let us suppose first that the earth's axis is perpendicular to the moon's orbit. The body tide will sweep around the earth, in its equatorial plane, once every month, but the matter of the earth will rotate through this tide once every day and in passing through the tide will be stretched, kneaded, and compressed, with the development of heat which is at the expense of the earth's rotational energy. In other words the tide acts as a brake upon the earth's rotation and will continue so to act until there is absolute coincidence of their periods, or until day and month become equal.

A part of the earth's surface is covered by a thin skin of water and the moon will produce tides in this water for the same reason that it does in the earth as a whole, but these water tides have practically no braking effect. That is, while the body tide must in no very distant time, as astronomical periods go, bring the periods into coincidence, the water tide never would do so, or, what is the same thing, would only do so in an infinity of time. We have therefore only to consider the effect of the moon's tide on the earth as a whole.

The body tide is very slight and we do not as yet know what it is. It may be a foot or two in height, but that is only a surmise. We have supposed that the earth's axis is perpendicular to the moon's orbit and for simplicity we suppose that the moon is the only attracting body. In the general case the earth's axis will be oblique to the orbit, and whereas in the first case we saw that the tide would act only on the earth's rotation, bringing about a coincidence of periods, we shall now see that the tide produces most important effects in altering the inclination of the earth's axis to the orbital plane. The action of the tide is what is known in mechanics as a couple and this couple tends to turn the earth about an axis which is perpendicular to the plane of the moon's orbit. Now we can decompose this couple into two components acting about two axes which are perpendicular to each other. We shall suppose one component to act about the rotational axis, and it is clear that the action of this component is simply to brake or slow down the rotation. The second component acts about an axis perpendicular to the rotation axis. Now it is well known both experimentally and theoretically what the effect of such a couple upon a rotating body like the earth is. It is fully dealt with in the science of gyroscopics, and we shall call this couple the gyroscopic component of the tidal couple. Its effect is to bring the rotational axis of the earth into a position of perpendicularity to the orbit. We cannot enter here into a discussion of precession and nutation which result from the equatorial bulge of a planet and cause the rotational axis to describe a cone about the orbital axis at a practically constant angle. If the earth is an absolutely rigid body, incapable of any deformation, it can be demonstrated that this angle will remain constant. But absolutely rigid bodies do not exist, and an elastic body cannot maintain its axial inclination constant. Notwithstanding this fact, it has been generally held until quite recently, and is still held in some quarters, that the inclination of a planet's axis cannot change, wholly ignoring the circumstance that such a constancy depends upon absolute rigidity.

We have very good reasons for believing that the four outer planets of our system originally rotated in a direction opposite to that of the earth, or in a negative direction. Neptune and Granus are still rotating negatively, while Saturn and Jupiter have turned over and are now rotating positively. It is clear that a rotating body can only be turned over through gyroscopic action, and in 1893 Prof. W. H. Pickering suggested that these planets had been turned over and were being turned over by the action of the tidal couple. It can be rigidly demonstrated that the tidal couple must do this.

The full mathematical investigation shows that in the case of two bodies, like the earth and the moon, with the axis of the earth starting from rest in any oblique position to the orbit, the tidal couple will straighten up the axis to a position of perpendicularity to the orbit, but that it will not come to rest there, but continue going over. As it swings outward the tidal couple will oppose this motion, annihilate it and finally bring it back to perpendicularity. Thus by a series of clamped swings it finally comes to rest in a perpendicular position. Thus if two bodies are started revolving about their common center of inertia, having rotations of any period about any axes, they will finally come to the condition where the revolu-

tional period and both rotational periods will all be the same and the two rotational axes will be perpendicular to the plane of the orbit. Both rotational axes will execute a series of swings or pendulations about the position of perpendicularity before finally coming to rest there. This is effected by the tidal couple. We see that while at first the motion was unstable, or changing, finally perfect stability of motion is attained and no further change is possible.

Starting with two bodies like the earth and moon, therefore, it is absolutely certain and can be as rigidly demonstrated as any other fact in mechanics, that if they did not begin with a condition of stable motion, as it is evident they did not, their previous history has been as follows: There must have been a time when the revolutional and the two rotational periods were all different. The inclination of the axes must have changed and in fact executed a series of swings about a perpendicular to the plane of their common orbit. Now the average position of the plane of their common orbit coincides with the ecliptic. Hence the axis of the earth must have pendulated about a position of perpendicularity to the ecliptic.

But a change in the inclination of the axis causes the seasons on the earth to vary. When the axis is perpendicular there are no seasons. There is perpetual summer or spring all over the earth. A tropical or semi-tropical vegetation will flourish at the poles as well as at the equator. But as the axis tilts over seasons begin and the differentiation between the seasons becomes more and severe as the inclination increases. Finally as the inclination reaches its maximum, large areas about both poles become glaciated. Then the axis swings back and the seasonal changes are repeated in reverse order. Glaciation gradually disappears and again there is perpetual summer all over the earth. The mathematician can assert this and does assert it as positively as he can assert the occurrence of eclipse at some remote period. It follows necessarily and inevitably from tidal action.

Let us now see if we have any evidence that the seasons have varied greatly in the earth's past history. Examining the geological record, we find that there is no doubt about it. The writer is not a geologist and any attempt on his part to trace the connection between the inclination of the earth's axis and past geological periods can only be tentative. He hopes that any errors will be corrected by geologists.

Going backward, we find that in the comparatively recent past there was very extensive glaciation about both poles. We infer that an extreme inclination coincided with the extreme glaciation. From this point there is a progressive amelioration of climate toward the poles going hand in hand with a decreasing differentiation of seasons, until finally we have cinnamons and palms growing where London now is, and a sub-tropical vegetation near the poles. We infer that at the end of the Cretaceous and the beginning of the Eocene, the earth's axis was perpendicular to the ecliptic. There were no seasons but perpetual spring or summer everywhere.

Going farther back we come to the Permian period and find evidences of extreme glaciation, if anything more severe than the pleistocene glaciation. We infer that the axis had an extreme inclination at this time, possibly greater than in pleistocene time. Going farther back we come to the subcarboniferous time, when it would appear that there were again no seasons. We infer that the axis was now perpendicular. But farther back in the cambrian or pre-cambrian period there seems to have been extreme glaciation and we infer that the axis was at that time extremely inclined.

S. Laing (Problems of the Future) says: "Nor is it a question of temperature alone, but of light and actinic rays of the solar beam which are equally essential for vegetation. A luxuriant forest vegetation, including such forms as the magnolia and cypress, could no more flourish, under any conditions now known to us, in Spitzbergen than they could if shut up for four months in a cellar. And yet with the present obliquity of the axis the sun must have been below the horizon in those latitudes from November till March."

The glacial periods mark off geological time as by a clock and the earth itself is the pendulum. Whether the swings were isochronous we do not know. The lengths of these periods may sometime be known, but the data for any estimate are extremely imperfect. We know that the day is lengthening, but at what rate have not the faintest idea. There is little doubt that we are approaching a genial epoch, but the tidal couple is so slight that observations extending over centuries would probably be necessary to determine the rate of decrease of the inclination. Such slight changes are of no importance to the astronomer, but to the geologist who deals with times millions and tens of millions ago, they are of supreme importance. In any system of bodies like our solar system it can be demonstrated that tidal action, which is a frictional force, will eventually reduce all motion to its simplest terms. This final condition is when the system has been reduced to two bodies which revolve about their common center of inertia in an orbit the plane of which coincides with the original invariable plane of the system. The final bodies will be ovals, their long axes always pointing toward each other, which revolve, as if rigidly connected, about an axis through the common center of inertia which is perpendicular to the invariable, or orbital, plane. The moment of momentum of the system remains invariable throughout the evolution, while the energy of the system is constantly dissipated until it attains the final irreducible minimum of two cold bodies.

TEACHING GEOGRAPHY BY MEANS OF MOTION PICTURES

THE educational value of the cinematograph has long been recognized but its introduction into our schools has been extremely slow. One of the principal obstacles to its general use has been the cost of the instrument and the fire-proof chamber in which it must be installed. This obstacle overcome there will be no lack of instructional films by which knowledge may be projected through the eyes as well as the ears of school children and thus be fixed more permanently on the youthful mind. There is scarcely a grammar- or high-school subject that cannot be filmed in part if not in whole. Even algebraic formulæ and equations are capable of pictorial presentation which will give the pupil a clearer concept of their significance.

In the September *Bulletin of the American Meteorological Society*, Dr. Marsden Manson of San Francisco announces a series of films that he is preparing for teaching all branches of geography and related sciences. He uses revolving models of the earth.

"In producing the films for this system," says Dr. Manson, "The models are mounted on a balanced axis, and are rotated so as to give diurnal and seasonal exposures to a beam of light, which illuminates them as the earth is in space. When in either or both of these motions, they are photographed with a motion picture machine. Data of any kind are permanently or temporarily depicted upon the model. The system is thus adaptable to a very wide range of subjects, and visualizes the data of each in an impressive form.

"The revolving, or at will, stationary, image of the globe is projected upon a scale of one-five millionth (or 2.6 meters = 8 feet 6 inches in diameter).

"The data for each film are compiled from standard texts, treatises and authorities, which are given in each case. The films can be used with the standard motion picture cameras.

"These films will be sold at reasonable rates, which will be announced as soon as the number required can be approximated.

"The system will be kept up with the advance of knowledge in the various fields and with new ones which may be developed."

FIG. 1. TABULA X OF THE *LITHOGRAPHIAE WIRCEBURGENSIS*

FIG. 2. THE ALLEGORICAL FRONTISPIECE OF DR. BERINGER'S BOOK

FIG. 3. SET OF CURIOUS BIRD FORMS SHOWN IN TABULA IV

The Figured Stones of Würzburg

An Account of the Most Remarkable Hoax in the History of Science

By Leon Augustus Hausman, Ph.D.

AT no period in the history of the growth of science did there exist a greater confusion of antagonistic theories and interpretations of natural phenomena than in the troublous times of that portion of the theologico-scientific struggle which followed the Reformation, a period embracing the latter half of the seventeenth and the earlier half of the eighteenth centuries. The rapid accumulation of new data in all fields of study clamored for correlation and interpretation; nor were correlations and interpretations wanting. Theories and counter-theories, hypotheses and counter-hypotheses were legion. Each new perplexing question propounded at once gave birth to a host of theories and interpretations more perplexing still!

Of the many vexatious problems which were presenting themselves in the rapidly growing fields of zoölogy and geology, perhaps the one which caused the keenest intellectual contention was the question concerning the origin and significance of fossils. The occurrence of the forms of bizarre fishes, plants and other organic beings imbedded within the strata of the sedimentary rocks proved to be too much for the early scientific minds to explain with any degree of mutual satisfaction. The general helplessness of the majority of the paleontological scholars when confronted by this problem can be inferred from the many amusing and non-committal generalities which they advanced in explanation. Thus the presence of fossil forms in the rocks was variously accounted for by "stone making forces," "formative qualities," a growth from seeds and the like. Even the much-abused doctrine of spontaneous generation, then in the heyday of its authority, was brought forward to lend its aid!

The influence of the Reformation was, at first, distinctly unfavorable, nay, even hostile, to the spread of the ideals of scientific progress. So robust was the opposition of the reformist leaders to anything like unfettered scientific research that the period immediately succeeding the Reformation was characterized by even more intolerance for the scientific viewpoint than that which marked the Reformation itself. The vestal flame of purely secular scientific philosophy was not entirely quenched, however, and later in the century it waxed stronger and more vigorous, expanding into a sturdy glow here and there, the earnests of a wider conflagration, which, at a later period, was to illumine the field of science with no uncertain light and point the way for such men as Buffon, St. Hilaire, Lyell, Darwin and a host of others.

In France the old spirit of antagonism toward secular and non-Aristotelian scientific thought still retained much of its pristine power, and until as late as the middle of the eighteenth century exercised a no mean measure of judicature over matters scientific. Thus it was that when Buffon, then professor at the Sorbonne, made a modest attempt to set forth what he considered to be a body of irrefutable geological statements, the theological faculty of that venerable university, incensed at his temerity, deprived him of his honorable position in the university, forced him to recant, and in the most ignominious manner to print and publish broadcast his recantation.

It was during this period of intellectual storm and stress that there was published at Würzburg a work which stands out in prominence as a memorial at once of an almost incredible hoax, a colossal farce, and a pitiful story of broken ambition and humbled pride, a work in one volume, quarto, entitled the "*Lithographiæ Wirceburgensis.*" Dr. Johann Bartholomaeus Adam Beringer, its author, lived during the first half of the eighteenth century, and at the time of the publication of the work which has made his name known, held the honorable degree of doctor of philosophy and of medicine from the University of Würzburg, occupied a chair in natural philosophy, and was private physician to the reigning Prince Bishop. He had already distinguished himself by his scholastic activities in the university, and was widely known as a capable and learned classical scholar, physician and natural philosopher. He had been the author of an able medical

treatise in 1708, the "*Connubium Galenico-Hippocratium,*" and had contributed to the literature of botany some fourteen years later in a systematic work entitled "*Plantarum Exoticarum Perennium Catalogus.*" By his colleagues in the university he was rapidly becoming known as paleontologist until his unfortunate venture upon the subject of the figured stones of Würzburg, in 1726. The episode upon which, like a rock in the pathway of a great ocean-going vessel, the career, reputation and life of the philosopher of Würzburg was wrecked, we will now recount.

Beringer had wholly, publicly committed himself to the belief that fossils were merely the capricious fabrications of God, hidden in the earth by Him for some inscrutable purpose possibly, thought Beringer, merely for his own pleasure; possibly as a test for human faith. His tenure of this position became so strong and so zealous that some of the students from the university, together, possibly, with some of the members of its faculty, and wags from the city, determined to put his faith in this doctrine to a trial *fort et dur*. They accordingly made numerous "fossils" of clay (Fig. 1) which they buried upon the side of a hill near Würzburg amid some thick bushes, a spot where they knew the worthy professor was wont to ramble in his search for specimens. In accordance with their hopes, Beringer chanced upon these "fossils" in one of his geological excavating tours; was completely deceived as to their true fictitious nature, and overjoyed to discover such suppositive proofs of the validity of his views, made known the facts of his discovery at the university. The jokers, perceiving with glee the success of their trick, now went even further and buried the most fantastic and extravagant clay figure which their whimsical imaginations could suggest (Figs. 3, 4 and 5). Not content with these alone, they fashioned inscriptions in Hebrew, Babylonian, Syrian and Arabic (Fig. 6), one of these being the name of God Himself! These they buried not far from the spot where they had concealed the first.

The elation of Beringer on discovering these latter "fossil" forms was unbounded. He was now completely convinced of the soundness of his original doctrine and at once made impressive preparations to publish a full account of his discoveries and to elaborate learnedly and at length upon their profound signification, animated by no meaner motive than to vindicate the position of the church regarding matters paleontological, and to settle once for all the vexatious question relative to the origin of fossils.

The semi-religious fervor of the once cautious man of science swept all before it, and, despite the temperate advice of more level-headed colleagues, Beringer hurried the pondrous work to its completion, and in due time the volume appeared. The book itself, a tome of commanding proportions and written in Latin, consists of an ingenious allegorical frontispiece (Fig. 1); a title page devoted chiefly to the record of Beringer's positions, degrees and learned honors; a dedication plate, followed by a nine-page dedication; a preface of about equal length; fourteen chapters, forming the body of the work; and twenty-one plates containing the figures. The title page informs us that the book is the: "*Lithographiæ Wirceburgensis, illustrated with the marvelous likenesses of two hundred figured, or rather insectiform stones,*" by "*D. Joane Bartholomaeo Adamo Beringer, Philosophiae et Medicinae Doctore . . .*" *etc.*, and printed in Würzburg in 1726. Some contribution to the work was made by one Georgius Ludovicus Hueber, who is also mentioned on the title page, but the bulk of the work is the result of the painstaking labors of the worthy and credulous Doctor of Medicine and of Philosophy.

The sounding and pompous dedication, nine full quarto pages long, is to D. Christopher Francis, Prince Bishop of Würzburg, "Most Revered and Most Eminent Prince and Merciful Lord." It begins with an exposition of the frontispiece, and its significance, which is an amazing and pretentious allegorical representation of the suppositive profound signification of Beringer's discoveries (Fig. 2). In the center rises a mound composed of the "figured or rather insectiform stones," upon which recline (as significative of their debt to the truth established by the work) the patrons of the various arts as well as teachers and children. Midway up the mound is the figure of a divine child-messenger tracing upon its tablets the inscriptions which it had pleased God to conceal in the earth for Beringer's discovery. In the foreground, to the right, stands a table, bearing the following passage from Ovid (*Metamorphoses, Bk.* I, 1.436): "It [the earth] brought forth innumerable forms; some like unto those which had existed before, and some new monsters."

But the most dauntless portion of this allegorical picture is the delineation of the arms of the reigning prince and the triangle of the Holy Trinity (the latter signifying the glory of Heaven), both represented as magnified by the work of Beringer, by being placed upon the summit of the mound.

After the preface, or *Prooemium* come fourteen chapters containing a full account of the discovery of the stones, the methods which the author had used to safeguard himself, as he thought, against making errors in the interpretation of his data, the description of the hill where the digging had been carried on, the progress of the work at the university, and so forth. He carefully refutes, in advance, the view that the figured stones might possibly be vestiges of the early pagan occupation of the land, i.e., the occupation by the Gauls, and elsewhere affirms it to be his unqualified belief that these fossils were made by the Creator and hidden in the earth at His command. Therefore, he concludes, it is not surprising that one should find the images of bizarre and unthinkable creatures, in no way related to those with which man is familiar. And thus it was that Beringer was not a whit perturbed when he unearthed such incongruous forms as we find figured in his plates; indeed their presence in the rocks but served to increase his assurance in the validity of his discoveries, stimulated him to greater endeavors, and strengthened his belief in the inscrutability of Providence. We can picture to ourselves the fervor of the old scholar as he labored over his great work, the *magnum opus* of a life of scientific devotion, his thoughts dwelling fondly, and not a little proudly, perhaps, upon the expected acclamation with which the book would be greeted by his contemporaries in science and philosophy. Not only would his proofs of God's direct agency in the formation of fossils be the *coup de grâce* to purely secular science, but it would undoubtedly forever lay the ghost of that troublous matter of the origin and meaning of fossil forms. No doubt the idea of the allegorical frontispiece came only after he had labored long upon the manuscript of the *Lithographiæ* and had pondered over the enormous authority which it would one day wield in the world of scientific thought. In chapter after chapter he anticipates and refutes objections to his views concerning the *lapides figurati Wirceburgensis*, always reverting to his tenet of their fabrication and concealment by divine decree. He describes gravely the Hebrew, Arabic, Babylonian and Syrian inscriptions which he had unearthed; commenting upon the nicety with which they had been fashioned, and upon their excellent state of preservation. Some of these inscriptions occur on shells and images of other animal forms. To Beringer the most significant of these inscriptions is the one in Hebrew, of God Himself. This, to the pious old professor, was the seal of divine approbation set upon his work!

And now comes the strangest part of this humiliating story. Some of Beringer's friends, partners to the secret, alarmed at the length to which he was pursuing this prodigious fraud, endeavored to dissuade him from the publication of his book. And even though others, who knew more intimately the secret of the trick which was being played upon him, acquainted him fully with its shameful history, yet he obstinately refused to give their stories credence. In one contemptuous chapter he dismisses all their evidence, denouncing it as a ruse of his rivals to deprive him of the honor of making known his dis-

coveries, and of publishing so important a contribution to science. And with a logic blinded by his vigorous faith, he argues that, since the workers employed by him to unearth the fossils knew no tongue save their own, they manifestly could not have made inscriptions in Hebrew, Arabic, Babylonian and Syrian. Needless to say, he had first convinced himself that no one save he and the workers, as he says, "some boys of tender age," had ever set foot upon the mountain whence had come the marvelous insectiform stones.

His work being at length completed, and in spite of the now more robust efforts of his colleagues to prevent publication, he published it, and appealed to the learned world. But the shout of laughter with which the book was received was not to be misinterpreted. In chagrin, anger and despair, the broken-spirited man exhausted virtually his entire fortune in the fruitless endeavor both to suppress the publication of the book and to buy up all of the copies which had been issued. For a short time he lived, the object of the mingled ridicule and pity of his contemporaries, and not long after died, as tradition tells us, of a broken heart.

But the wrecking of Beringer's reputation did not cease with his death, for a graceless bookseller, Hobhard of Bamburg, seeing his opportunity to make capital of Beringer's shame, bought up all the available copies from the heir of the original publisher and not only reissued them, but compiling a second edition, brought out the work under a new title and turned this also into circulation!

Poor Beringer! His woes have been great, and his demand upon posterity is one for large pity. Very few of the prominent personages in the history of science stand so in need of our heartfelt sympathy as Johann Bartholomaeus Adam Beringer, Doctor of Philosophy and of Medicine in the University of Würzburg, and private physician to the Prince Bishop.

(For accounts of Beringer's work see, first of all, the "Lithographiæ" itself. None of the accounts are complete, and give but short résumés; these are: *Allgemeine Deutsche Biographie*, Vol 2; Ersch u. Grüber, *Encyclopädie d. Wiss u. Künste*, Leip. 1818-90; Reusch. *Bibel u. Natur*, Freiburg, 1866; Reuss, *Litterarisches Curiosum*, in the *Serapeum*, 1852, Vol. 13; Zöckler, *Geschichte d. Beziehungen zw. Theologie u. Naturwissenschaft*, Gutersloh, 1879, Vol. 2, p. 171.

ANNOUNCEMENT OF PRIZE CONTEST

WE have just received from M. O. de Bast, the president of the Electro-Technical Institute, founded by the late George Montefiore at Liege, Belgium, an announcement of the triennial prize offered by them containing the followiny conditions:

Article 1. A prize whose sum total consists of the interest accumulated upon a capital of 155,000 francs, invested in Belgium government funds at 3 per cent, is awarded once in three years as a result of an international competition to the best original works presented, dealing with scientific progress and the advance in the technical applications of electricity. Mere compilations or popular treatises will not be considered.

Article 2. The prize bears the name of the George Montefiore Foundation.

Article 3. The only works which will be considered are those which have been presented during the three years preceding the triennial meeting of the jury. All works must be written either in French or in English, and may be delivered either in manuscript form or as printed matter. In any case all manuscripts must be typed and the jury will decide as to whether they shall be printed.

Article 4. The jury is composed of ten electrical engineers, five from Belgium and the remainder from foreign countries, under the presidency of the Professor-Director of the Montefiore Electro-technical Institute, who is ex-officio one of the Belgium delegates. Save for certain exceptions stipulated by the founder, the Belgian delegates must be chosen among those engineers possessing the diploma of the institute.

Article 5. In exceptional cases the prize may be divided under a 4/5 vote in each of the two sections, foreign and national (who must for this purpose vote separately). By the same majority the jury is empowered to award a third at the maximum of the sum at their disposal for a discovery of capital importance to an individual who failed to take part in the competiiton or to a work which without entirely fulfilling all the conditions nevertheless, contained some new idea which may exert an important development in the domain of electricity.

Article 6. In case the prize is not awarded or if the jury awards only a partial prize, the extra sum of money is to be added to the prize of the following triennial period.

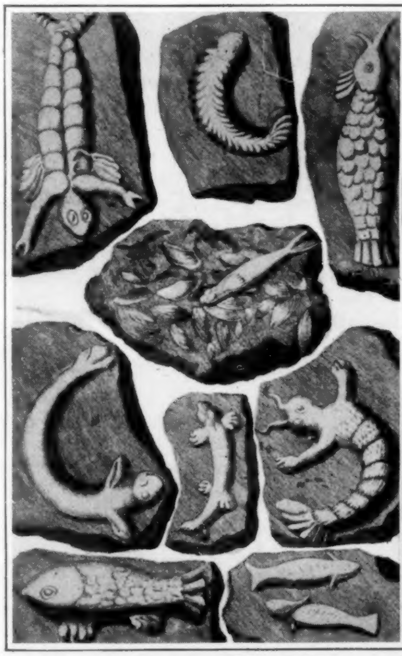


FIG. 4. TABULA XXI—CURIOUS FISH FORMS

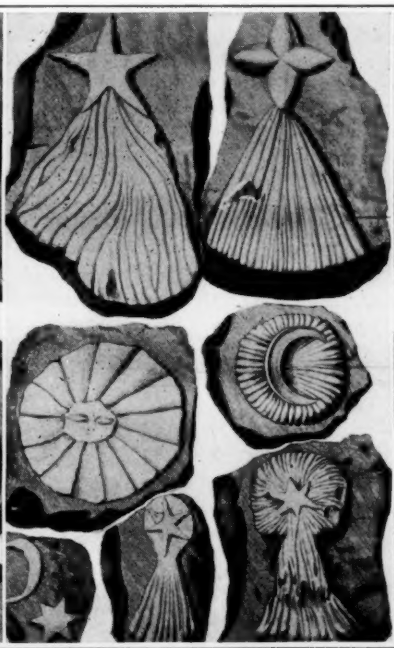


FIG. 5. TABULA III—FOSSIL HEAVENLY BODIES

FIG. 6. TABULA VII—MYSTERIOUS FOSSIL INSCRIPTIONS

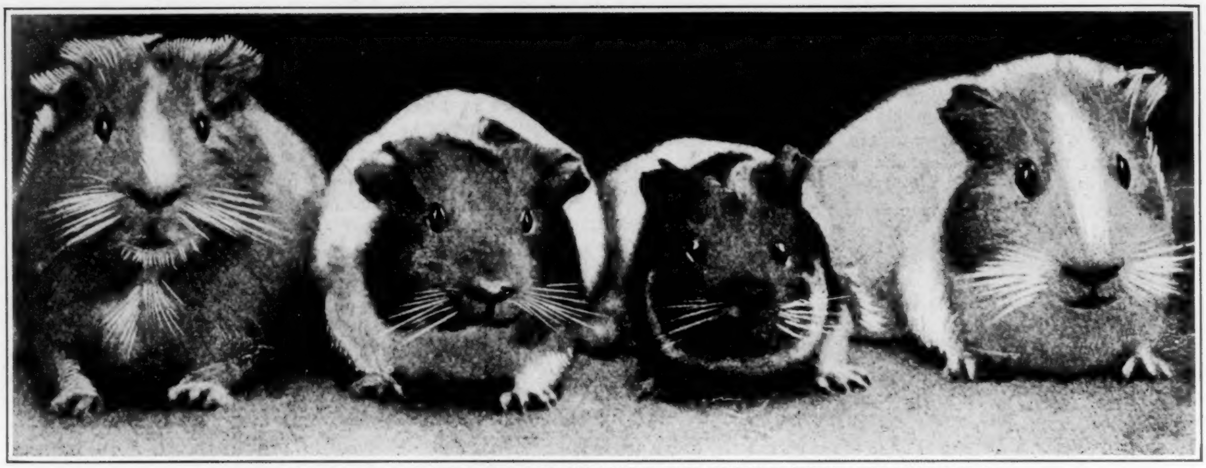


FIG. 1. GUINEA PIGS IN WHICH THE PRIMARY SEX ORGANS WERE TRANSPLANTED

The Modern Elixir of Life*

Experiments in the Rejuvenation of Aged Animals by the Grafting of Special Organs

By Donovan McClure

AT last the dream of the ages seems about to come true—man's tireless endeavor to baffle Father Time is on the brink of a success, just as that other apparently hopeless dream which has inspired the breast of mankind since the first dawn of intelligence—the dream expressed by the Psalmist in the words—"Oh that I had wings like a dove's"—is now a matter of daily experience, so it seems that the magic hand of science has found that Elixir of Life the quest of which brought Ponce de Leon to a far distant Land of Flowers and for which Faust bartered his soul.

But the new method of rejuvenating senile men and animals lies in the knife of the surgeon rather than in the vial of the apothecary. A few months ago the sensational announcement was made in Paris that Dr. Serge Voronoff had succeeded in restoring the lost youth and vigor of an old goat by means of the grafting of interstitial glands. Later the experiment was repeated upon an aged man, the gland of a chimpanzee being used in this case. At once a cloud of witnesses arose, some to scoff and doubt, others to declare that Dr. Voronoff was claiming undue honors in a field where he was a follower rather than a pioneer.

The writer of the present article has the highest respect and admiration for the brilliant achievements of Dr. Voronoff, who is now in this country, and who recently consented to make a special demonstration of his special methods before a distinguished body of medical men in New York City. It is the purpose, however, of this article to relate the work done along similar lines by an equally distinguished Austrian physician. As a matter of fact a great many men of science have been engaged, ever since the beginning of the present century, it is probably safe to say, in the general field of the experimental study of animal grafting. Skin grafting has long been practised with admirable results. More recently bones, muscles, other tissues have been successfully grafted. The cruel exigencies of the Great War naturally gave an enormous impetus both to research and to practical achievement in these fields, and truly marvelous results have been obtained in facial surgery. But most thrilling of all are those experiments dealing with the transplantation of whole limbs or of entire organs and it was due to experimental surgery in this domain that the discovery was made that in the transplantation of sex organs, from young to senescent animals, there lay a potent means of restoring the vanished vigor and vitality of youth.

Since the public is already more or less familiar with Dr. Voronoff's work, we wish to call attention here rather to the experiments and achievements of certain other men, working along the same lines—achievements which undoubtedly the famous Parisian physiologist would most cordially recognize.

A few weeks ago a Chicago doctor published a statement that he had undertaken similar investigations several years ago, and had even performed an experiment upon himself, grafting a reproductive gland with markedly favorable results. For reasons of professional etiquette however, he confined his description of his experiments to well-known medical journals. Dr. Carrel's experiments in this general field are well known.

Furthermore recent dispatches from Portland, Oregon, state that a physician of that city, Dr. McCorkle, has been successfully transplanting what he refers to as "glands of youth" from the body of the goat to that of human beings. Both men and women have been treated and each of 41 cases has resulted in rejuvenation of the patient. Seven of the patients were women and their ages varied between 45 and 48, while the men were from 61 to 74 years old. In a recent press interview Dr. McCorkle is quoted as declaring his belief that the operation will not only increase vitality but prolong life, besides relieving too high a blood pressure. He says: "I transplant the glands just like an appendicitis operation and in almost the same locality. They become imbedded in the peritoneum. These glands may be absorbed in a year's time. Persons formerly morose and worried regain their spirits and face life with a new outlook. In addition patients with an extremely high blood pressure have had almost unbelievable reductions in pressure."

But interesting as these experiments are, they are surpassed in certain directions by those of Dr. Eugene Steinach of Vienna. Even before the war this physician was regarded as one of the most eminent authorities in Europe. He founded the Laboratory of Comparative Physiology at Prag—one of the first on the continent, and later became director of the Biological Institute at Vienna, where he conducted the experiments described below.

It is of peculiar interest and importance to find that he secured rejuvenation in both men and animals not merely by

FIG. 2. MALE RAT TWO WEEKS OLD CONVERTED INTO A FEMALE BY GRAFTING

the grafting or transplanting of special glands but also by a system of applying ligatures to special ducts, as well as by a specific application of X-rays. This latter method is highly significant, since many persons who might shrink from having animal glands transferred to their own bodies would contemplate X-ray treatment with equanimity.

Dr. Steinach has recently published a remarkable book entitled "Rejuvenation by Means of Experimental Revivification of Senescent Puberty Glands." The term "puberty glands" is intended by Dr. Steinach to include not only the usual organs of procreation in both sexes, but also those interstitial glands or cells called the Leydig cells in the male sex and the Lutein cells in the female sex. These also contain an internal secretion which exerts a marked effect upon sexual differentiation and maturity.

Steinach undertook some curious experiments with young guinea pigs and rats. He removed the primary sex organs from male animals two weeks old and transplanted upon them the ovaries of female animals of the same sort about four weeks old. The animals thus operated upon, after recovering from the operation, developed into females, as is shown in Figs. 1 and 2, which are taken from Vol. XVII of a work published by Julius Springer of Berlin, entitled "Studies in Internal Medicine and Children's Diseases." Somewhat later Steinach repeated this experiment in the reverse direction, i.e., the ovaries were removed from female animals and the primary organs of male animals were transplanted upon them. The result of this was the development in these female animals of male instincts and of the desire to fight with other males.

These experiments were carried out in 1915 before an assembly of naturalists and physicians in Vienna, in the Biological Experiment Station. The experiments were regarded as being of the greatest significance and importance with respect to the light thrown upon the original sexual characteristics. Steinach declared his opinion that the sexual dfferences between males and females are not occasioned by the predominant portions of the sexual organs but by the interstitial cells. Since both glowing youth and mature age on the one hand and senility on the other are chiefly controlled by these glands, it occurred to the great physician to inquire whether it would not be possible to check the advance of age by means of revivifying these glands. He asked the question to himself, "Is an actual rejuvenation of the body possible?"

The experimenter turned his attention to experiments upon rats, studying the progress of the vital process in these creatures from birth, through youth, maturity, and advancing age to death.

One of the most marked signs of senility in rats is the bristling and bushy appearance of the hair and the fact that it begins to shed the latter, becoming bald in spots, as shown in the accompanying picture of a senile rat. The bent back and drooping head are other well-known signs of decay, as are a decline of appetite and corresponding loss of weight, a dull and clouded eye, and a feebleness of the muscles. Equally significant of the decline of the vital powers is the loss of interest in the surroundings—even the presence of the female fails to rouse an aged male to a show of his earlier ardors, and instead of exhibiting a hearty lust for fighting with a rival, he withdraws with abject cowardice before the menace of the latter.

But is it possible once more to light the fires of youth in this dull-spirited and decrepit creature? Steinach's experiments answer this pregnant question in the affirmative. He describes three methods in fact by means of which this marvel can be achieved. The first and simplest of these consists in the ligaturing of the spermatic duct (*vas Deferens*). The second method accomplishes the same end by means of exposure to the X-ray. This method is also applicable to females. The third method is that referred to above—namely, the transplanting of the germ gland from a young animal upon an aged one. In the course of a few weeks after the performance of either of these operations the rejuvenating influence was apparent in the entire aspect and demeanor of the animal. As shown in our illustration (Fig. 3) the head was raised, the eye open and bright, the pose of the body rigorous and alert, the former bald spots covered with a fresh growth of hair. Naturally these surprising and desirable results suggested the application of this new elixir of life to the relief of the symptoms of old age in men. In 1918 Steinach's assistant, Dr. Lichtenstern, undertook, on the advice of the former, to apply these methods of rejuvenation to human beings. The results of the experiments were most admirable. Old men thus operated on not only looked fresher and young, but felt an increase in strength and vigor, while aged trembling hands grew steady, feeble tottering steps became firm and failing masculine instincts and impulses acquired new vitality.

FIG. 3. OLD FEMALE RAT REJUVENATED BY TRANSPLANTING INTO IT THE ORGANS OF A MALE RAT

It was found that the animals treated by these methods also lived from one-fourth to one-third longer than the normal expectation of life would indicate.

The remarkable alteration in the secondary sex characteristics of male rats of the same litter was shown most plainly. In both males and females indeed the operation led to "the blossoming of a new youth even restoring potency and fruitfulness" in one and the other.

How long these restored powers will continue in human beings only the future can tell, and in this connection it is sad to state that the bitter want which at present holds Vienna in its grip has led to the closing of the Vienna Biological Institute, so that Steinach is left without funds, materials, assistant, or animals with which to continue his fruitful experiments. The veteran Leipzig physiologist, Wilhelm Roux, therefore appeals to the public for donations to a suitable foundation to enable Steinach to continue his experiments.

CURING COLDS BY ACID FUMES

It has long been observed that the workmen in the carbonization rooms of factories for making artificial wool are uncommonly healthy. It occurred to a German chemist that this might be connected with the fact that the air of such rooms is saturated with acid fumes. This idea seems singular enough since we are all instinctively careful to avoid breathing the fumes of acid. However, an inquiry made by a German professor, Dr. von Kapff, in regard to the conditions of the hands occupied in various industries where acid fumes are liberated, showed that such employes were not only remarkably free from infectious disease, but also from those of the respiratory organs. He even found, in fact, that many cases of tuberculosis were actually cured in such an atmosphere. This fact had not failed to be noted by the men engaged in such industries, and had been taken advantage of by transferring alien employes to branches of the business where such fumes existed, such a transfer being especially useful in diseases of the organs of respiration themselves.

Obviously, the proportion of acid in the air must not exceed a certain definite percentage. Dr. von Kapff was so impressed by the result of his inquiry that he experimented with his own children when they were suffering from the too common affliction of the "sniffles" or a cold in the head. Most persons know only too well that such colds usually last from two to three weeks, but in the children thus treated all symptoms disappeared in a day or two. So successful was the treatment, in fact, that its use has become widely extended in hospitals and sanitariums in Germany, in which regular inhalations of suitable gases are administered. The treatment has been attended with remarkable success, not only in the case of acute afflictions, but also in chronic maladies, such as bronchitis, bronchial asthma, whooping cough, inflammation of the throat, and hay fever.

In many of the public schools in Aix, the air was maintained in a slightly acid condition for two hours daily in certain classes. It was found that the pupils in these classes not only remained entirely free from infectious diseases, but actually showed a considerable gain in weight over the children in the control classes. The same experiment was tried in Stuttgart during the influenza epidemic and the children thus protected remained free from the grippe, which made great ravages on the other children. In spite of these surprisingly favorable results a word of caution is necessary, for it has been found that if the exposure to the acid fumes be too long continued there is a danger of producing a more or less permanent acid condition of the mucous membranes.

The proper proportion is from 0.1 to 0.2 grams per cubic meter of air. Suitable acids to be employed include hydrochloric acid, hydrofluoric acid, formic acid, acetic acid (vinegar).

It is particularly interesting to notice that hydrofluoric acid which possesses the property of etching glass, is as beneficial as the others. It was found, in fact, that in those factories where this powerful corroding agent is used for this purpose, there were many cases of the cure of tuberculosis and in one instance a man suffering with the terrible disease of lupus was healed. Curiously enough more than sixty years ago a French chemist pointed out the good effect of hydrofluoric acid in cases of tuberculosis, but his observations appear to have been almost entirely forgotten.

Various acids are variously adapted to one disease or another, but it appears to be the case that the inorganic acids are to be preferred in tuberculosis and hay fever.

Dr. von Kapff also made many successful experiments with the application of the acid treatment to animals. He succeeded in curing a case of mouth and foot disease in a few days by the acidification of the air. Horses suffering with glanders were cured in two days instead of the twelve ordinarily required.

It may be called to mind, too, that during a cholera epidemic which occurred in England in the middle of the last century, it was observed that the hands in wool factories were spared, and it seems probable that this may now be ascribed to the sensitiveness of the cholera bacillus to acids.

Diluted hydrochloric acid when applied to wounds causes rapid healing without suppuration; also, burns over which picric acid is poured heal quickly without pain and without blistering. Most people will remember that it has long been popular among common folk to hang up cloths soaked in vinegar in sick rooms, a practise which is now seen to have been unconsciously scientific.

PRESENCE OF COPPER IN FOOD PLANTS

Since cases of copper poisoning not infrequently occur either in occupational trades through the ingestion of verdigris from unclean cooking utensils, etc., or from its administration with homicidal intent, not to mention the accidental taking of it in the form of the Paris green used to spray plants, it often becomes a matter of legal interest to know the possible sources of copper in the body and the amount which is taken in by the organism under natural conditions without harm. A contribution to this subject appears in a report made to the French Academy of Sciences, July 19th, 1920, by M. B. Guérithault. The investigator found that copper is a normal constituent in small amounts in a great variety of food plants. His method of study was the ordinary process consisting of the following steps: Incineration, treatment of the ash with hydrochloric acid, separation of the copper in the form of the sulphide, transformation of the sulphide into the nitrate, electrolysis, and finally, quantitative determination of the copper, either by directly weighing or by colorimetry after the addition of ammonia to the nitric solution.

The amount of substance operated upon varied from 200 gr. to 1 kg. and the incineration was accomplished in a muffle furnace heated with wood charcoal. The ash was treated first with half strength hydrochloric acid evaporated to dryness, then taken up by pure hydrochloric acid and evaporated to dryness a second time. The evaporation was accomplished by means of a special aluminum water bath with porcelain supports. While this method requires lengthy manipulation it gives very exact results. Varying amounts of copper given in the table in the original article were found in the following vegetables: The leaves of lettuce, spinach, leeks, and celery; the roots of the carrot, turnips, radish, salsify, leeks, beets, and cress and the stalks of the latter; bulbs of onions and the tubercles of potatoes, in green beans; in the fruits of the pumpkin, cucumber, tomato, apple, pear, cherry, grape, orange, olive, banana, date and chestnut; and in the seeds of peas, beans, soya beans, lentils, wheat, barley, rye, oats, maize, cress, radish; as also in decorticated rice and in various nuts, including sweet and bitter almonds, walnuts and hazel nuts. In general, the proportions vary from 8.7 mg. to 63.6 mg. per 100 gr. of the ash, and from 1.1 mg. to 17.1 mg. per kilogram of the fresh substance. The seeds were found to be especially rich in copper.

Relieving Fatigue by Means of Toxins*

A New Method of Stimulating Animal Organisms and Increasing Their Capacity for Work

By Dr. Martin Claus

THE specific treatment of infectious diseases, i.e., of diseases occasioned by definite germs consists in the introduction either of small quantities of the said germs (mostly after they have been killed) . . . into the body, or else by the injection of a specific curative serum, such, for example, as diptheria anti-toxin. The first process is termed *active* immunization. After the injection of the aforesaid disease germs the body itself is stimulated to the production of special anti-toxins. The second form is called *passive* immuization; in this previously prepared curative agents obtained from animals are introduced into the body.

General or non-specific therapeutics has of recent years come into special attention and appears destined to throw considerable light upon the more delicate biological processes by which immunity is obtained. This branch of physiological science involves especially what is known as the therapeutics of albuminous bodies (the injection of serums, of milk, etc.) and has been developed especially by R. Schmidt (*vide* Umschau, 1916, No. 50). This subject also includes the effects exerted upon the body by the various forms of radiant energy, including natural and artificial sunlight or daylight, X-rays, red rays, etc.

The best angle from which to study this at present is through the consideration of the increased efficiency or "work done" obtained by the activation of protoplasm, a concept first introduced into medical science by W. Weichardt.

PROTOPLASM ACTIVATION

By protoplasm activation we understand a stimulation of all of the elementary building stones of the body, i.e., of the cells, which is expressed in an increased capacity or effectiveness of the natural functions of the organs, and which may be conditioned by the most various causes, primarily by means of albuminous cleavage products. This augmentation of yield is, aside from the various peculiarities of the organism concerned and other secondary conditions such, for example, as the state of the individual's nutrition, a sort of incorporation of the albuminous substance which is chiefly dependent upon the amount and the nature of the cleavage products which are assimilated or created in the body. But, above all, this increase of efficiency depends upon whether the organism is already "sensitivized," that is, upon whether any injurious substance is already present.

Such an organism—usually it is the diseased organism which is sensitivized against the infectious substance—usually reacts (in non-specific therapeutics) with great vigor by means of its specific defensive powers. Thus we often see the processes of inflammation greatly augmented or the production of the immunizing bodies already present much increased. All of these processes are best explained by the theory of increased efficiency. These ideas are based upon the hypotheses stated in the work by W. Weichardt called *Ueber Ermüdungsstoffe* (Concerning Fatigue Toxins). This investigator succeeded some time ago in obtaining from the expressed juice of the muscles of extremely fatigued animals certain albuminous cleavage products of high molecular value incapable of being filtered through the membrane employed for dialysis; to these he gave the name of "kenotoxins." By injecting these kenotoxins into normal animals he was able to produce in them all the symptoms of severe fatigue: Profound stupor, enervation, a low temperature, retarded respiration. When the doses were very large they even caused death. But when animals thus treated recovered they were unusually lively, and were also more immune to fresh injections, in large doses, of the kenotoxins than were animals not previously treated; furthermore they showed increased capacity for work as was proved by applying graduated electrical stimuli. In the same way the injection of *small* quantities of albuminous cleavage products of high molecular value increases the capacity for work.

By the breaking down of the albumens injected into the body cleavage products are formed which cannot be readily classified. But in all cases small doses of high molecular products increase the capacity for work. When we speak of the successful use of radiotherapy, E. S. Rollin's success with exposure of patients to sunlight, as coming under the head of the non-specific augmentation of the capacity for work we have in mind the idea either that the efficiency is augmented by a direct stimulus of the cells, or else that the activation of the protoplasm is effected by the appearance of albuminous cleavage products in the body itself with the results described above.

This increased efficiency, or capacity for work, in the body may be exhibited either passively or actively. In the first case there is an elimination of injurious or efficiency-diminishing cleavage products through the circumstances that they are in some measure transformed into inactive compounds by means of electively operative factors. Such factors can bear no relation to the cells. This sort of action is seen only in an already fatigued organ in which cleavage products are already present, and it operates only to inhibit the phenomena of fatigue; hence it can at best merely restore the efficiency to the normal. Substances of this kind are found for example in blood serum and thymus gland extract; many definite chemical compounds also have this property, *e.g.*, substances which contain a double N H group united to an atom of carbon, such as succinimid, etc. Far more important is the *active* augmentation of efficiency which is exhibited in a *heightening of the natural functioning of the entire organism*, or of any given organic system. This is accomplished by protoplasm activation, and leads to a much more pronounced increase of efficiency and can also be induced in an isolated non-fatigued organ. This is now employed in medical practice in the above mentioned forms of "albumen" and "radio" therapeutics, and can also be accomplished by the injection of colloidal metals and other *non-specific substances.* It must probably be distinguished therefore from the action of *specific* agents, such as that of caffeine and of camphor upon the muscles of the heart. Definite examples will perhaps make the matter clearer to the layman. For example, Weichardt and Popielski showed that the activity of the isolated heart of a frog can be increased by high molecular albumen cleavage products; of much practical importance too are the experiments showing that by the injection of albuminous bodies into female goats which have not "come in fresh" for a long time, the flow of milk can be increased to a marked degree as a function of the increased activity of the gland. This increased efficiency due to high molecular cleavage products can also be shown by electrical stimulation of the muscles of the calf in the leg of a mouse.

These experiments also shed much light on the effects of training of race horses and of oarsmen. Training merely consists of a gradual increase in muscular activity and the consequences thereof. During this muscular activity decomposition products are formed in the body in small amounts; in other words when the practice is not too severe or long continued, these products increase the efficiency. When after a certain period for repose the muscular activity is renewed,

*Translated for the *Scientific American Monthly* from *Die Umschau* (Frankfurt am Main), May 8, 1920.

there is found to be an increased efficiency, which also leads to an increase in the size of the muscles because of the stimulation of metabolism and thus helps to increase the capacity for work. The beneficial effect of massage on muscles can also be explained in this way. This helps us likewise to comprehend the ill effects of over-training . . . in this case such large quantities of albuminous cleavage products are produced in the organism that they exert a crippling and injurious effect upon the muscles and upon the entire body.

The case is entirely analogous with respect to mental overexertion, and this explains why it so often happens that an excellent student fails in his examinations, especially when he has spent his nights "cramming" previously. These facts should be pondered and utilized by pedagogues.

But the non-specific increase of efficiency by means of the stimulus of small quantities of cleavage products is not the only possible way in which to increase the capacity of work in single organs or in the whole organism, though probably the most important method. A large number of methods for producing this increase of efficiency have been collected by Weichardt and published in the Munich *Med. Woch.*, No. 4, 1920. A few examples will show the practical importance with respect to the conquering of infectious diseases of the rôle played by the increase of efficiency, by means of albuminous bodies:

Thus, as far back as 1890 Rumpf treated typhus fever by means of flooding the system with pathological germs of less toxic character, such for example, as the bacillus which produces green pus (B. *Pyoceaneus*). At the present time Kraus employs the so-called hetero-vaccine-therapy, *i.e.*, the treatment of an infectious disease with a micro-organism which has nothing to do with the disease itself. Very instructive in this connection is the case, for example, of a soldier suffering from typhus with a very high degree of fever, who had an attack of malaria, whereupon his temperature soon became normal, the intestinal symptoms were mitigated, and the greatly depressed mental condition of the patient was both objectively and subjectively improved. The patient's temperature continued permanently normal and he was entirely cured after a rapid convalescence. In this case the malaria excitants (plasmods) discharged from his own body into his circulation acted as a hetero-vaccine which was decomposed and in the form of cleavage products increased the efficiency of the body.

This non-specific increase of efficiency may be effective in the healthy body as well as a sick one, in so far as it possesses sufficient strength of reaction to influence all the cells. In the case of a healthy person this alteration in the tissues subsequent to an injection is not so obvious with respect to increase of muscular capacity but can be proved in a general manner. Much more delicate, on the other hand, is the augmentation of efficiency in the nervous system, in the process of metabolism, in temperature, in the coagulation of the blood, and the extremely important behavior of the internal secretion glands (suprarenal bodies, ovaries, testicles, thyroid, pineal gland). In the case of a diseased organism the natural defensive elements of the bodies are augmented. This is shown, for example, in an increase in the number of the anti-bodies whose function it is to neutralize bacterial poison; but it can also be shown by non-specific therapeutics (the injection of serum or of milk) which occasion an increase in the capacity for coagulation of the blood, which is of great importance in many cases, as in the hemorrhages which often occur as a result of the intestinal injuries caused by the typhus bacillus, or in the alteration processes which occur in the blood vessels through the progress of tuberculosis of the lungs. Von der Velden first showed the selective effect of albuminous bodies in diseased organisms with respect to the local foci of attack—a process which has a parallel in the peculiar affinity exhibited by many medicines such as iodine for tissues which have undergone alteration by disease. The tissue thus altered resembles a foreign body in the organism; the latter seeks to get rid of it as soon as possible and accomplishes this by sloughing it off or by absorption, a process which is chiefly accomplished by the effects of ferments which decompose albumens, as in the case of the activity of the white blood corpuscles. This view explains likewise the success obtained with ordinary horse serum in cases of diphtheria. In this instance there is a non-specific increase of efficiency with an especial local effect, without a neutralization of the diphtheria toxin. However, such a treatment of diphtheria should not be employed except where the regular curative serum is not at hand, since it is undoubtedly true that the most successful treatment is that with a *specific* serum, whose anti-bodies directly lay hold of the toxins thrown off by the diphtheria bacillus and make them harmless.

This hypothesis has an extremely important practical application in what is known as combination therapeutics, such for example, as that employed in acute rheumatism of the joints, *e.g.*, when the diseased joint is first highly stimulated by the administration of albumen, and at the same time treated by a specifically acting medicine (in this case salicylic acid).

We may mention also successful experiments in treating typhus by injections of milk. This may possibly suggest a way of employing this increase in the efficiency of the defensive elements of the body to protect the latter against the bacilli of diphtheria and of other maladies, or to detect and cure latent malaria.

CONDITIONS OF CELL STRUCTURE OUTSIDE THE BODY.

CULTIVATION of living tissues outside the organism is being carried on with great success at the College de France by a leading scientist, Prof. Champy, and he has already obtained noteworthy results. As a basis, he employs Dr. Carrel's method of maintaining detached tissues or parts of organs in a living state in which their cells also multiply to an indefinite extent. But the present experimenter while making microscopic observations upon the cells resulting from the growth of the tissue or organ, came upon an unexpected phenomenon. According to Dr. Carrel's first results, it was supposed that the cultivated tissue went on reproducing cells of identical nature, such as were characteristic of any particular organ, for instance the thyroid gland. But Prof. Champy observed that this was not the case, and that the cells resulting from the cultivation outside the body now lose their specific properties and become modified, or differentiated, as he terms it, and now form cells which have all the properties of cancerous cells, that is, they are cells of an indifferent nature whose only function is to multiply in an active manner. It may be asked why a given organ such as the kidney, for instance, will keep on growing indefinitely and its cells differentiating at the same time, while within the human body its growth is limited. While the reason is not known, the fact remains that in an adult animal a given organ will be maintained in a certain proportion to the weight of the rest of the body without exceeding this limit. Should one kidney be removed, the other thereupon undergoes hypertrophy in order to effect a certain compensation which tends to restore the balance in the functions, so that the second kidney can be said to have had the property of growing to a larger volume, but this growth was prevented by the presence of the other organ. In fact, such connected organs and tissues act to limit each other's growth, and the living organism such as the human body can be said to have the property of maintaining the proper equilibrium of the organs by preventing their indefinite growth. But if this preventive action is suppressed, as when the organs are detached from the body, the growth will now continue, and this takes place by the formation of cells which are no longer of a characteristic nature but are of the class known as cancerous cells. It will be seen that these researches throw considerable light upon the question of the growth of living organs or tissues outside of the body, and will thus form a valuable contribution to this subject.

The Ancestors of the Sequoias*

Trees Which Have a History of Ten Million Years, and Are Today Passing into Oblivion

By Edward W. Berry

Professor of Palæontology, Johns Hopkins University

IN the days when the world was considered to be only about six thousand years old and when the few known fossils were considered to be the visible evidence of Noah's flood, it was scarcely remarkable that no one was interested in tree ancestors. In these days, however, with the passing of our virgin forests and the great interest taken in preserving some of our threatened species from extermination, it is a matter for surprise that the thought that these noble races of plants had ancestors is but rarely entertained.

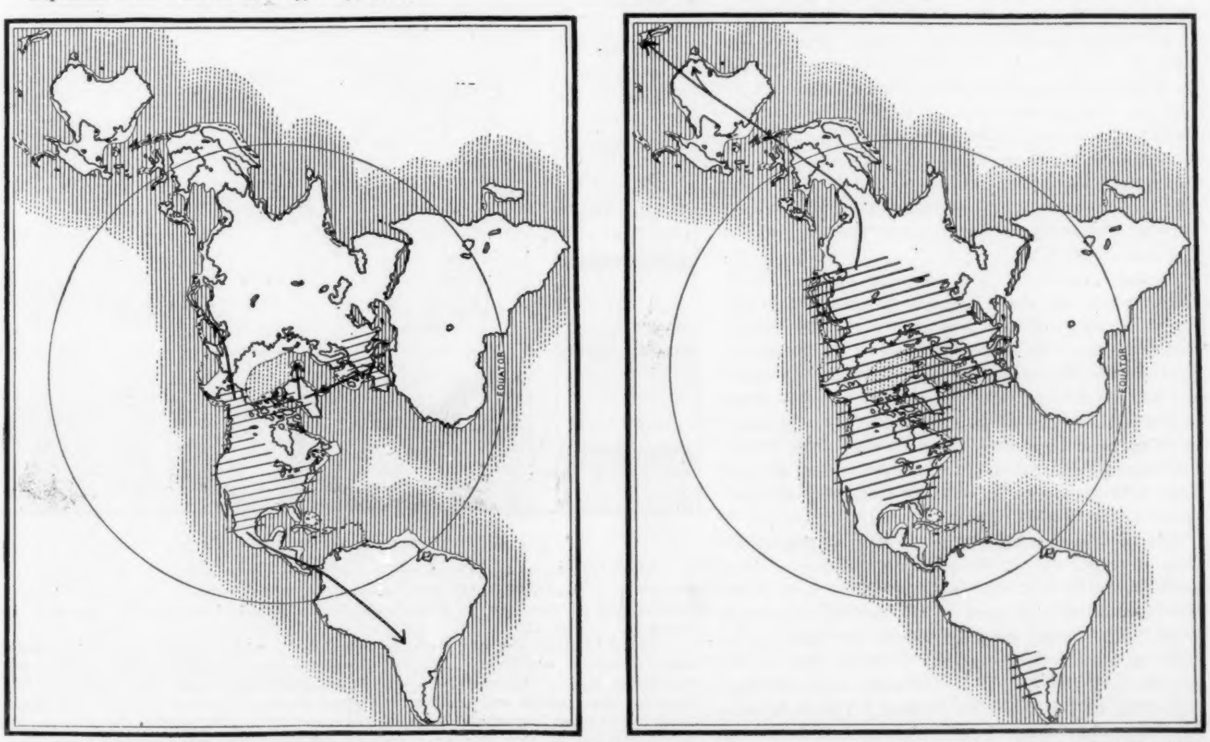
Tree genealogies, it is true, present little of the dramatic as compared with the wonderful American evolutionary series of the horses or camels, and yet most of our familiar forest trees are of more ancient a lineage, and some, like the Sequoias, go back almost to the birth of the tiny progenitors of the warm-blooded animals. Although the book of the future is tightly sealed, that of the past needs but understanding wedded to imagination to be legible even though its torn pages are the rocks of the earth's crust.

The chapters of this book of history where the records of the Sequoia occur are those chapters from late Jurassic time down the ages to the present. The entries of the Sequoia ancestry comprise innumerable leaf-bearing twigs, many cones, fragments of wood, and occasionally, as in Yellowstone Park and at Florissant, Colorado, mighty silicified trunks petrified into forests of stone and buried by tremendous showers of volcanic ashes.

Sequoia remains resist decay admirably, so their chances of preservation as fossils in the rocks are much better than those of most plants. The cones, especially, are very common in the geological record, and a favorite method of preservation is as ferruginated mud casts. I have collected these from the Lower Cretaceous of Maryland, from the Upper Cretaceous of Kansas, and from the early Tertiary of Dakota. Cones almost identical with those of the existing redwood are abundant in the present arid Bad Lands of western Dakota, denoting very different climatic conditions in that region in past ages.

The earliest known Sequoias come from the late Jurassic. They first became widespread, however, during the later Mesozic, radiating from their original home, which was probably in the Arctic archipelago, southward to western Europe and North America, and along the eastern coast of Asia. (See sketch map below at the left. Little is known of Asia at that time, but North American Cretaceous records are innumerable, extending from the Atlantic to the Pacific, and southward to southern Mexico, and there is one record from

*Reprinted from *Natural History*, July, 1920.



MAXIMUM DISTRIBUTION OF SEQUOIAS DURING MESOZOIC TIMES, THE AGE OF REPTILES (SEE MAP AT THE LEFT), AND DURING CENOZOIC TIMES, THE AGE OF MAMMALS (MAP AT THE RIGHT)

The two extant species of Sequoia, the big tree and the redwood, unique among trees for age, and size, are the restricted survivors of a once widely distributed genus. Their dispersal began in the early period (Jurassic) of the previous geological era, the Mesozoic or Age of Reptiles, and during this age they probably radiated from the Arctic archipelago southward over western Europe, North America, and the eastern coast of Asia. Twigs, cones, and seeds were left abundantly among the Lower Cretaceous or Comanchean rocks. During the Tertiary period of the succeeding Cenozoic era or Age of Mammals, the Sequoias reached their maximum distribution over practically all of Europe and North America, a large part of Asia, and southern South America. ***Sequoia langsdorfii***, the direct ancestor of the redwood, was predominant in the great circumpolar forests of the late Mesozoic, and ***Sequoia magnifica***, almost identical with the redwood, left the petrified trunks found in Yellowstone Park and at Florissant, Colorado. During the cold Pleistocene which preceded our recent geological period, the Sequoias disappeared except in the Pacific coast area where they are still dominant.

Argentina, which, if the identification is correct, means a migration from North America across the equatorial region and the origin of the Tertiary species found in Chile.

It is during the succeeding older Tertiary, however, that the Sequoias reached their widest limits of distribution. (See map on page 207. Europe and North America were fairly covered at one or another time during this period. Asia has furnished many records, and somewhat questionable evidence points to the extension of the Sequoia range to Australia and New Zealand. No records for any period of Sequoia history have been furnished by southern Asia and Africa, and all of the known Tertiary records are outside of the tropics and almost exclusively in the North Temperate and Arctic zones, for Greenland, Iceland, and Spitsbergen were colonized, as well as Siberia, Alaska, and the Arctic coast of North America, during the older Tertiary. Sequoia twigs are common in the Tertiary coal measures of southern Chile, as I was at pains to verify during a recent visit to that most interesting region. They are found in Europe as late as the time immediately preceding the Glacial period.

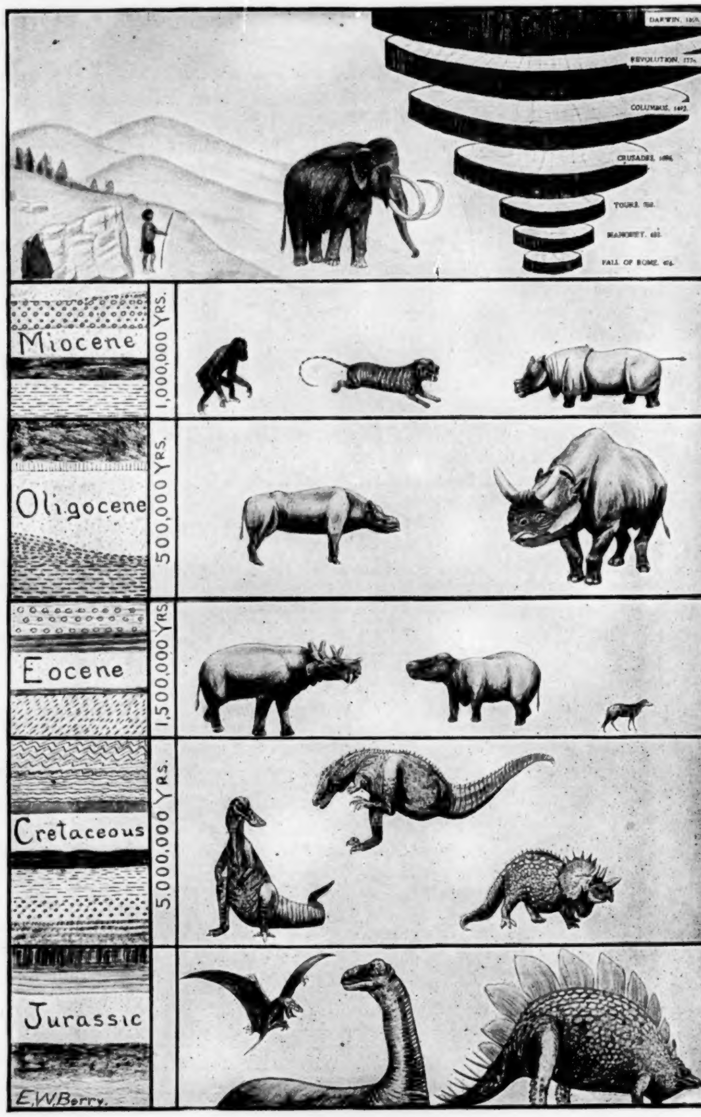
Today the two existing survivors of this ancient race are our oldest trees; one might appropriately term them existing fossils. The accompanying figure shows the evolution of animal life witnessed by these ancestral Sequoias. It was printed fifteen years ago and is republished through the courtesy of the *Scientific Monthly* (formerly known as *Popular Science Monthly*). The picture owes its original existence to the creative art of Mr. Charles R. Knight and the liberality of Professor Henry Fairfield Osborn, and although our conceptions of some of the details of these restorations have changed somewhat with a better understanding, the drawing will still serve as a dramatic portrayal of the past. The millions of years during which Sequoias have flourished have seen striking changes in the animal kingdom, from the uncouth dinosaurs and flying reptiles of the Mesozoic through the evolving mammals of the Tertiary to the Age of Man.

Equally great, if less obvious, changes have taken place in the vegetable kingdom, for the first Sequoia lived amid a flora of ferns and sycads, and there were no representatives of the flowering plants—the mammals of the plant world—in those far off days. The flowering plants are the most specialized, the latest to appear, and the dominant existing race of plants—the race that made possible human civilization, since all of our food plants, upon which modern as well as primitive cultures rest, belong to this race.

I have said nothing of the majesty of this royal line of trees, nor of their individual size or longevity. It is a story that has often been told. The largest of the trees in the Sequoia National Park had already sprouted before the first Olympiad or before Carthage was founded, that is, in the days of the Judges in Palestine and the first flowering of the Assyrian Empire. The redwoods are somewhat more abundant than their brothers, the "big trees," less massive and shorter lived, but they are more like those fossil species whose structures have been investigated. Moreover, they are more accessibly located, more easily lumbered, as yet unprotected by law, and hence more in danger of total destruction.

That we do not treasure the Sequoias or any of our forest trees sufficiently is a reflection upon our democracy. I sometimes wish that we moderns were less pragmatic and that our bump of reverence was less vestigial, for then not only the redwoods but all of our trees might become as sacred as they deserve to be, and even a lumber trust might hesitate to turn these abodes of the gods into waste places. Our forests, like the stars or the changing seasons, are wonders whose lessons and value have become dimmed because of long familiarity. If we saw them but once or twice in a lifetime they would be treasured accordingly.

One has but to dwell in a treeless desert for months to have awakened within him such a love for the forests as will last forever.



CONTEMPORARIES OF THE SEQUOIAS

Above at the right, are shown a series of tree sections illustrating the growth of a single living big tree (*Sequoia gigantea*) in relation to human history. The largest of the trees in Sequoia National Park had sprouted before the first Olympiad, 776 B. C.

Below is given a partial geological section in which are grouped the animal contemporaries which have accompanied the Sequoias at various times since their rise among the great dinosaurs and pterodactyls of the Jurassic. The Sequoias overtowered and survived the giant reptiles of the Cretaceous, the "dawn horse" and huge ungulates (Amblypoda and Titanotheres) of the Eocene, the *Brontotherium* of the Oligocene, and the rhinoceroses, saber-toothed tigers, and early primates of the Miocene. In the last-named period they reached their greatest geographical expansion. The fossil remains, especially the cones, of the Sequoias are exceptionally resistant, and so render a very complete geological record.

Knots and Boles on Forest Trees

Causes of the Curious and Varied Formations of Grain in Timber

By Charles E. Chidsey

THE above title represents a phenomenon of forest growth which by reason of its variety and manifold complexity, is of interest even to the casual observer of nature. Many ingenious theories have been advanced to explain the curious markings in the interior of trees, such as "birds-eye maple" and others, and the subject engaged the attention of the great French naturalist, Buffon, who in conjunction with Duhamel made an interesting investigation which was published under the comprehensive title, "Researches Into the Cause of the Irregularities of the Woody Fiber Observed on Cutting Horizontally Into a Tree, with Respect to the Inequalities in Thickness, and to the Varying Number of Layers, Both of the Heartwood and the Sapwood."

Buffon and Duhamel presented an array of evidence in support of their theory that in my judgment leaves it incontestible; and after spending months in studying such growths at first hand, I have gathered fresh evidence to confirm their statements. In this paper I have translated the remarks of the two Frenchmen, following this with an account of my own observations, illustrated from my own photographs.

After remarking that foresters were not agreed whether boles and knots were to be found most frequently on the north or shady side of the tree, or on the southern and shady side, Duhamel says: "I could add to these observations many

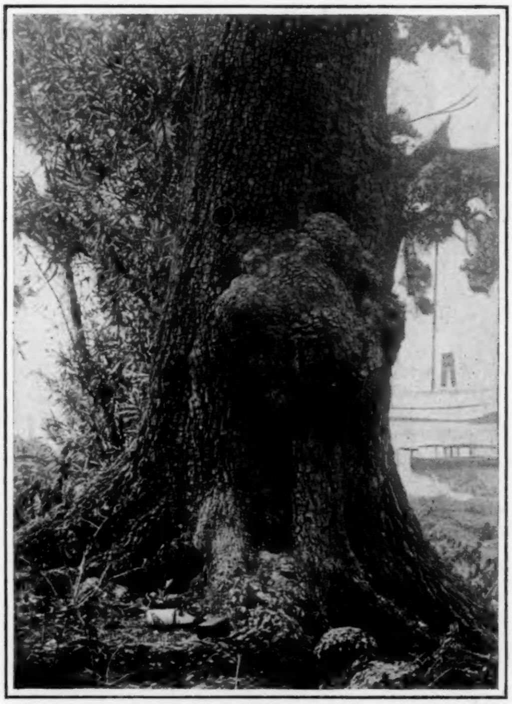


FIG. 1. UNUSUALLY LARGE BOLE ON A MISSISSIPPI LIVE OAK

others, such as Buffon made in Burgundy, and an even greater number which I have made in the Forest of Orleans, which show by examination of a large number of trees that the question of north or south side has nothing to do with the matter. It is altogether a question of the position of roots and branches; the layers of the wood are always thicker on the side where the roots are most numerous and vigorous. In this direction the experiments of Buffon are decisive.

"He chose an isolated oak, of which four roots were almost equal and disposed, one to each quarter of the compass; and having cut the surface of the earth he found, as he had suspected, that the center of the layers of woody fiber coincided with that of the tree's circumference—in other words, that it had grown equally on all sides.

"This finally convinced us that the true cause of the eccen-

FIG. 2. NATURE AT WORK BUILDING UP A BOLE AROUND THE STUMP OF A FRACTURED LIMB

tricities of the layers of woody fiber is the position of the roots, and sometimes of the branches. . . . On splitting the trunks of several trees through the middle, I found that in some the heart followed almost a straight line; but in a greater number, where the wood was more perfect and easily split, it showed inflections in the form of a zigzag. Further, in the center of almost all these trees, both Buffon and I have observed that in a thickness of an inch or an inch and a half toward the center there were always many little knots, so that the wood has been found to be entirely free only when of little thickness.

"These knots arise no doubt from the breaking off of branches put out in large quantities in the youth of the tree. After dying these, in time, are covered again, forming the little knots to which one attributes in part the irregular direction of the heart, which is not natural to trees. Such loss of limbs may be attributed to many causes: to starvation of the less sturdy among a superfluous number of limbs, to the effects of cold, to breaking by animals, to the force of the wind, etc.; and since the heart of such a branch does not correspond with that of the trunk, there is a change of direction. True, these branches adjust themselves; but the tree is ever obliged to nourish some lateral branches in forming its main stem, so there is always the inflection in the heart of the tree.

"We have then observed that the direction of exposure causes no sensible variation in the thickness of the layers of woody

fiber; and we believe, when those layers are noticed to be thicker on one side than on the other, that it came about almost always from the position of the roots, or from the direction of the branches. These branches may actually have come forth and been broken off, or not; in any event, their place was covered over again."

The authors recount many interesting experiments that they conducted, but I need only quote their conclusions. "These experiments," they say, "prove that the nourishment borne to one part of a tree communicates itself to all other parts, and consequently the sap has a lateral movement of communication. But this lateral movement does not interfere enough with the direct progress of the sap to prevent it from making the greater abundance of tissue in that part of the tree, and to that bundle of fibers, corresponding with the roots that furnish it. This it is that causes the part of the tree corresponding in position with a particularly vigorous root to profit more than the rest, as may be especially seen in the trees along the border of a wood; for here the best roots are almost always on the open side, away from the other trees, and this is likewise the side where the woody layers are thickest.

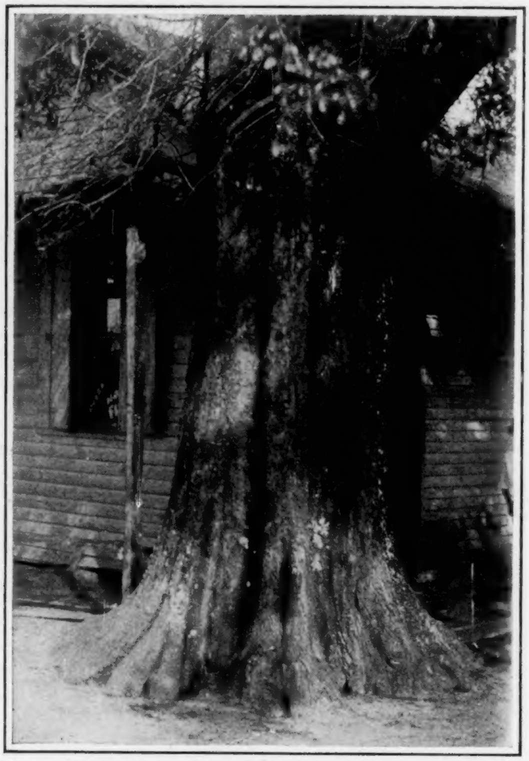


FIG. 3. A RED OAK TREE THAT CONTAINS SIX SEPARATE TRUNKS, GROWN TOGETHER

"It also appears from our experiments that the layers of woody fiber are thicker in those parts of the tree to which the sap has been borne in greatest abundance, whether from the roots or from the branches.

"It is this abundance of sap that causes the sapwood to transform itself the sooner into heartwood; it is upon this factor that depends the relative thickness of heartwood and sapwood in different terrain and in divers species. For the sapwood is nothing less than imperfect wood, a wood less dense in order that the sap may traverse it, there to set down materials to fill the pores and create true wood. That part of the sapwood through which the sap passes in greatest abundance must therefore transform itself more promptly into perfect wood; and that transformation, in the same species, must depend upon the soil."

Such are the theory and experiments of Duhamel and Buffon on the formation of knots and boles, and incidentally on the variety of grain found in woody fiber. In order to illustrate and prove the correctness of their conclusions, I have taken a series of photographs which I will explain: Fig. 1 is of an unusually large and interesting bole on a live oak (*Quercus virens*) that stands on the bank of the East Pascagoula River. In the long ago there was a branch or limb which decayed through disease or injury; and the tree, seeking to heal its wound, annually covered it and the protruding branch with layers of woody fiber. The proof of this is shown in Fig. 2, representing an oak about three hundred yards from the first; here we can actually see nature at work building a bole on a tree by laying layers of woody fiber over a wound and a fractured limb.

Should tree No. 1 be cut down and sawn into lumber that part of the planks near the base of the bole would present a texture or grain of unusual variety and beauty, made by the alternate circles of wood and sap built up over the fractured limb. These rings of wood and sap are of varying thickness; and as the saw passes through them, making a plank, and cutting through the walls of the rings, we have the alternate lines of light and dark wood which form the grain of the wood, and which correspond to layers of wood and sap in the tree trunk.

In Fig. 3 we have a large red oak, near Pascagoula, Miss., or rather a series of oaks; for this tree is made of six separate oaks that have grown up together and made one solid trunk. Some day when this falls and is made up into lumber the marvelous beauty of the grain of its wood will attract the notice of even the least observing.

Fig. 4 shows two pines growing together, which will some day make a single tree.

Fig. 5 shows seven live oaks grown separately from a single root. At present they form seven distinct trees; some day they will grow together and form one solid trunk like that of Fig. 3. In this picture one can observe on the trunks of the center trees small boles that were made by decaying branches, leaving a hollow which the tree is cicatrizing, and which in course of time will be a large bole and give variety to the marking of its grain.

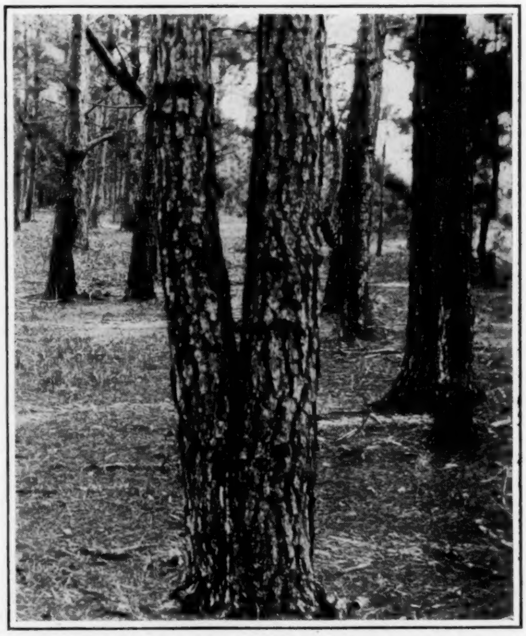


FIG. 4. A DOUBLE PINE SHOWING SMALL BOLES WHERE IT HAS LOST LIMBS

EVAPORATION OF GASOLINE FROM CRUDE PETROLEUM

While engineers, chemists and automobile men throughout the country have been bending their best efforts toward developing some liquid fuel as a substitute for gasoline to meet the ever increasing demands of the fast growing automotive industry, the United States Bureau of Mines comes forward with the declaration that the entirely preventive losses in the evaporation of gasoline from crude petroleum from the time the petroleum leaves the wells until it arrives at the refineries reaches a total of more than 300,000,000 gallons each year, or sufficient to keep 1,200,000 automobiles in commission for a year if each car uses 250 gallons of gasoline.

These, according to the Bureau of Mines, are merely the preventive losses from evaporation alone and do not take into consideration other losses, many of which in part may be avoided. The total loss from evaporation amounts to more than 600,000,000 gallons of gasoline for the country, according to the investigations of the bureau, which has calculated that one-half of this, or 300,000,000 gallons of gasoline, may be saved.

The worst feature of this is the fact that the gasoline wasted is the most volatile and consequently the best quality of gasoline obtainable. It follows that the prevention of this loss, which is economically possible, would not only increase the gasoline supply materially but would also increase the general standard of the gasoline.

The Bureau will issue, shortly, careful directions to the oil men as to how this deplorable situation may be remedied. It is estimated by the Bureau that the 600,000,000 gallons of gasoline lost through evaporation each year is worth as a national asset about $150,000,000.

J. O. Lewis, petroleum technologist of the Bureau, in his statement on these losses, says: "At a time when there exists so much apprehension in regard to the gasoline situation, it is comforting to learn of any ways in which the supply may be increased. In an intensive effort to find ways of increasing and improving the quality of gasoline, the Bureau of Mines has made an investigation of the losses of gasoline by evaporation from the crude oil in the field. Extensive experiments and investigations in the principal fields have disclosed that a great quantity of the gasoline now escapes into the air. This can be conservatively estimated at about 20 per cent of the gasoline in the crude oil. Furthermore, probably half of this, at least, can be economically recovered, and this quantity will not only increase our supply but improve its quality somewhat.

"From the time that the crude oil reaches the surface of the ground at the well, the oil passes through a series of tanks and pipe lines until it reaches the refinery, sometimes thousands of miles away. In the course of its journey the oil is exposed to sun and air, and the gasoline, being very volatile, vaporizes and escapes into the atmosphere.

Notwithstanding it has been generally known that such losses occur, no one up to the present time has called attention to their magnitude. The methods of handling crude oil in the field have grown up from the time when gasoline was a drug on the market, and there was consequently no incentive for conserving it. Until recently no one stopped to consider whether the methods devised for conditions twenty and thirty years ago were still satisfactory for today."

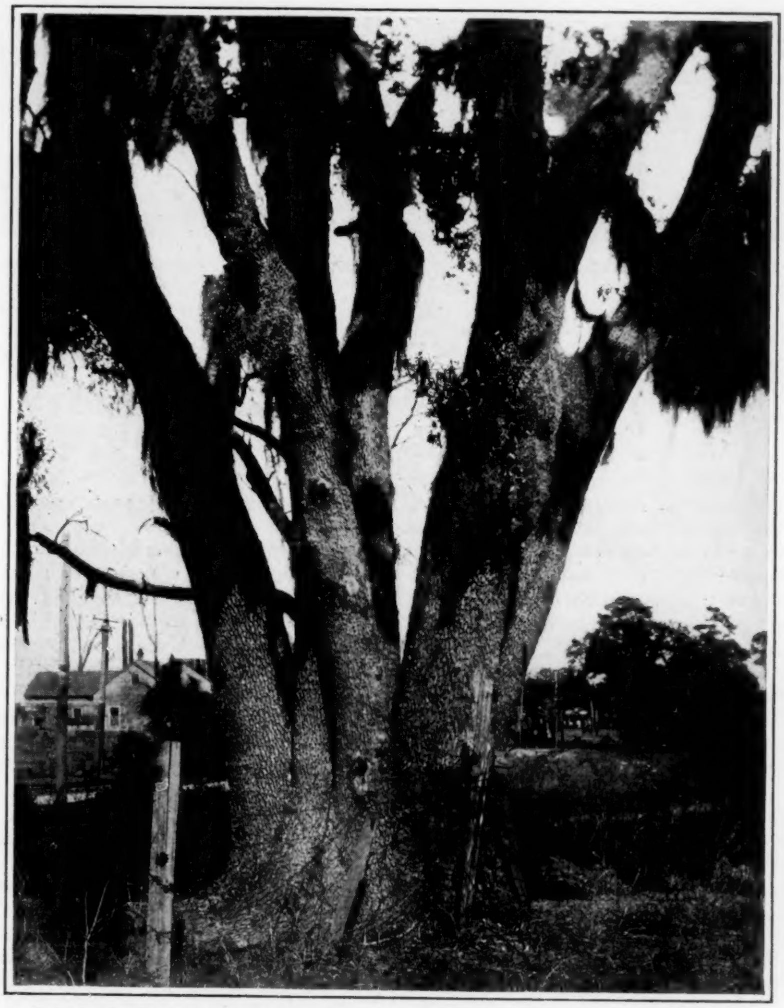
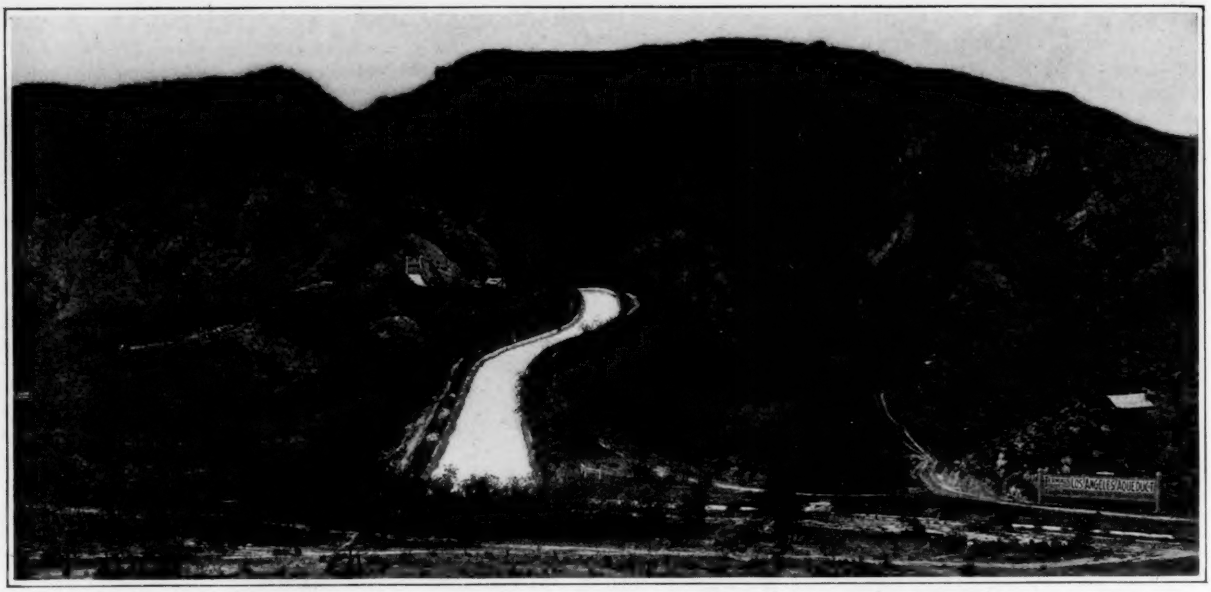


FIG. 5. SEVEN LIVE OAKS FROM A SINGLE ROOT, WITH SMALL BOLES ON THE CENTER TREES. SOME DAY THEY WILL HAVE GROWN TOGETHER INTO A SINGLE TRUNK, LIKE THAT OF FIG. 3

NEW VULCANIZING PROCESS

Mr. S. J. Peachy, of the Manchester College of Technology, has found that, by exposing rubber alternately to the action of sulphur dioxide and hydrogen sulphide, it becomes rapidly and completely vulcanized, even at the ordinary temperature.

The process appears to be of fundamental importance for the following reasons: (1) It is a true sulphur vulcanization. (2) It eliminates the use of heat, and to a great extent the use of mechanical pressure. (3) It employs two gases which can be produced on a large scale cheaply. (4) It is rapid in action. (5) It enables the manufacturer to employ organic filling agents. (6) Coal tar dyestuffs and even natural dyes can be introduced producing delicate tints and shades hitherto unobtainable. The process can be extended to the vulcanization of rubber in solution.—Abstracted by *The Technical Review* from *Optician and Scientific Instrument Maker*, July 2, 1920.



A TERMINAL NEAR FERNANDO, OF THE LOS ANGELES AQUEDUCT, WHICH SUPPLIES WATER TO MANY CITRUS-FRUIT GROVES

California's Citrus Fruit Industry

How the Citrus Growers of California Combined to Place the Industry on a Paying Basis

By Robert G. Skerrett

IMAGINE three parallel rows of boxes spanning the continent from the Atlantic to the Pacific and you get a mental picture of the twenty-odd million cases of oranges and lemons shipped out of California in the course of a twelve-month. Not only that, but this outpouring of luscious fruit instead of being merely a seasoned tribute to our exacting palates is a year-round source of delight.

Strange as it may seem, recognizing the splendid present proportions of the citrus-fruit industry of the Golden State, the business has in the main been built upon a freak of nature. Just about a century ago there developed in the Brazilian village of Bahia an exceptional type of orange, conspicuous by reason of its many excellent qualities—among these an absence of seeds. It was subsequently found possible to reproduce the kind by grafting the proper buds to other trees, and, in time, the fame of the species reached William Saunders, then in charge of the propagating gardens of the U. S. Agricultural Department in Washington.

Through the aid of a missionary stationed at Bahia, Mr. Saunders had sent to him in 1870 a dozen of the trees bearing the unique fruit, and while these imported orange trees had a short life still they survived long enough to permit their multiplication through careful grafting. Two of these American-grown trees—which were carried to California in 1873—are today still producing their wonderful fruit, now commonly known as the Washington navel orange; and from the stock introduced by the Government expert has come the many thousands of acres now yielding annually an immense golden harvest. According to the latest figures, the California groves send broadcast yearly a matter of quite 30,000 carloads of navel oranges.

Now the navel orange ripens so that it can be picked, packed, and distributed from November until May of each year; and a knowledge of this fact has led many people to conclude that oranges bought later on are fruit that has been held in cold storage, and, therefore, less desirable. Here is where the California grower has met Nature half way and found it practicable to cultivate another variety, the Valencia, which matures so that it is ready for the market from May until November—thus furnishing another source of supply which assures us fresh oranges every month of the year. The Valencia variety originated in the Azores and actually reached our shores about the same year that the first of the navels were brought north from Brazil. Indeed, the pioneer Valencia trees were planted in California somewhere around 1872, but their propagation did not gain commercial prominence until rather recently. For a long while, the seedless character of the navel made so strong an appeal that most efforts were centered in satisfying the popular demand for that particular fruit. But the unwisdom of this course became apparent when those active in the citrus industry realized that the business would be a much better balanced one if the market could be maintained summer and winter.

Then it was that the virtues of the Valencia stood forth. Some decades of experience had proved that species to be very juicy, richly flavored, and in most respects quite the equal of the navel. While not generally seedless, the Valencias commonly have only from three to six seeds, and are outwardly to be distinguished by their paler color and the lack of the peculiar formation at one end which marks the navel orange. In a normal season California ships 15,000 carloads of Valencias, and, in addition, 2,400 carloads of other varieties, such as the Mediterranean Sweet, the Blood, the St. Michael, and Seedlings.

Substantially all of the lemons grown in this country come from California. Prior to the severe freeze of 1894, which wrought havoc among the citrus orchards of Florida, that State contributed a share of our lemons. Since then, in addition to our native-grown fruit, Italy and Sicily have sent us lemons, the bulk of which has been absorbed in the markets of the Atlantic States. California lemons have, nevertheless, steadily reached farther and farther east, and ordinarily fully two-thirds of the domestic supply is produced there. The yield from those sun-kissed groves averages an annual ship-

ment of 9,000 carloads, and the output is on the increase. There are today 22,651 acres planted to lemons and bearing, while there are 16,799 acres on which the trees have not yet reached the fruiting stage.

Science has lent its aid generously to the development of the California citrus-fruit industry; and what might be called efficiency engineering applied to agriculture has done its full part in bringing the enterprise to its present high plane. The story is a heartening one, for it constitutes an example of success in the face of impending disaster. But let us confine our story first to the trees, *per se*.

The primary problem, of course, is to obtain hardy basic stock capable of making the most of the California soil and able to hold its own well against parasites and disease-inducing spores or scales. To this end, orange seeds are secured from carefully selected seedling oranges of healthy, sturdy type, and planted closely in the rows of a specially prepared bed. The resulting plants are left to grow as a rule for a year, and then the most promising of them are transferred and set out in a nursery. Here they remain another twelve months; and when the trees are two years old they are grafted or "budded" agreeably to the fruit-bearing variety desired. The matter of choice of the buds is of prime concern, and at this point actual knowledge, not guesswork, figures conspicuously.

Prior to this time, the orange grower has been watching all of his trees, if he is up to date in his practices, and he has a record of each one of them and knows how much it yields in the course of a season as well as the quality of the fruit. From the best of these trees he selects buds for grafting upon the seedling stock in the nursery. The bud from the pedigreed tree is inserted in an incision which is made in the bark of the seedling about four inches above the ground, and when the graft has "taken" the top of the young tree is removed. From the bud grows a shoot which eventually becomes the entire upper structure of the tree; and quite regardless of the kind of the root stock, the tree will produce oranges according to the variety of the bud. The dominating nature of the bud is strikingly evidenced in the case of the lemons cultivated in the Golden State.

In California, strange as it may seem, lemon trees are obtained by grafting lemon buds of the desired species to hardy orange root-stock—the orange seedlings being raised from the seeds of fine parent trees. Thus the rugged roots and inherent strength of the orange tree form the foundation for the superstructure of the high-quality lemon bearer. With the lemon trees, as with the orange trees in a grove, it is the custom to rebud and to lop off the top of any tree that does not measure up to standard. In this way it is possible to get rid of "slackers" and to graft them anew with the buds of a profitable and superior strain. In determining these characteristics, the suitability of the fruit for commercial purposes is given due weight, and regard must be had to the manner in which the oranges and lemons stand transportation to the widely scattered markets to which they must be sent.

An orange tree generally begins to bear paying crops six years after planting. The production increases as the tree becomes larger and older; and a well-regulated orchard usually attains its full-fruiting stage in about a decade. Lemon trees rarely yield at a profitable rate before they have reached their seventh or eighth year, but from that time on, if they are of pedigree stock, they bear abundantly. In fact, the lemon tree never rests. It blossoms the year round, and, therefore, displays buds, blooms, and fruit, both green and ripe, at the same time. From the day a blossom sets until the lemon is large enough to pick there elapses usually a period of about nine months. The citrus trees are planted in rows arranged so that the soil about them can be cultivated in four directions; and there is an average of 105 trees to the acre. There are 175,000 acres devoted to orange growing and 39,450 given over to the raising of lemons in California. All told, the orchards have a flourishing array of 22,500,000 trees.

During the dry season the orange and lemon groves are irrigated every thirty days, the water for this purpose being distributed in furrows made by special implements between the rows of trees—the number of these furrows depending upon the age of the orchard. After each irrigation the soil is thoroughly cultivated to conserve the moisture. Irrigation entails a heavy outlay, for in some cases the water has to be brought a distance of a hundred miles, and the charge per acre may run up as high as $40 annually. And then there are other expenses directly incident to the preparation of the ground and the protection of the trees.

Whether the orchard be used for the growing of oranges or lemons it is necessary to exercise a great deal of care through the agency of systematic pruning to assure the proper upbuilding of the frame of the individual tree. This begins the first year after the citrus sapling is set out in the grove and continues for the remainder of its life. Pruning has for its purpose the encouragement of stocky main branches strong enough to carry the weight of the fruit without breaking or swaying violently in the wind. It also serves to stimulate the growth of fruit-bearing wood all over the tree, especially on

DESTROYING PESTS WITH HYDROCYANIC ACID GAS

The trees are covered with canvas, then the gas is pumped into these envelopes and allowed to act for three-quarters of an hour.

WASHING OFF INSECT PESTS AND FUNGUS GROWTHS

Prior to shipping the three-year-old trees are scrubbed with a lather filled with a suitable germicide.

the inner branches, which produce lemons and oranges of the finest form and texture.

Spraying for some insect pests, sulphuring and spraying for other insects and fungus must be resorted to to safeguard the groves from destructive attack; but the Bureau of Entomology of the U. S. Department of Agriculture has effectually relieved the orchard growers of one exceedingly menacing pest, thanks to the scientific research that led to the introduction of the Australian ladybird. The fluted scale threatened some years back the utter destruction of the orange industry in the West. Then, an explorer, sent by the Bureau to the Antipodes, discovered the scale's natural enemy in the form of a little spotted beetle native to the southern hemisphere. Since the importing of this tiny creature the fluted pest has been practically eradicated, and our citrus growers in California are saved many millions of dollars each twelvemonth.

But there are scales that cannot be held within check except by means of fumigation. This is accomplished by covering each tree with a canvas bag or tent which is then filled with hydrocyanic acid gas, and the fumes left to do their work for a period of about three-quarters of an hour. It is said that an orchard once properly fumigated will remain clean for three years before it is necessary to repeat the operation; and it seems that by this method a grove can now be kept free from scale at a cost far below that formerly possible. As far back as eight years ago, when this system of gas warfare was in its infancy, so to speak, a single grower stated that he had been able in that way to save a quarter of a million dollars.

In the wintertime, when there is occasional danger from frost, the temperature in the citrus orchard is kept above the danger point by lighting coal, charcoal, oil, or wood heaters, which are placed between the rows of trees. The damage to fruit buds by frost is more apt to be severe when the sun's rays, following a night of cold, are allowed to fall upon the trees. To prevent this sudden change from freezing to thawing a system of "smudging" was resorted to about 1908, based upon a series of experiments made by an eminent Frenchman. The principal involved is to create a smoky veil which will serve the twofold purpose of preventing the radiation of heat from the earth's surface at night and of shielding the fruit buds from the sun's rays during the early hours of the day.

CUTTING AWAY THE TOPS OF UNDESIRABLE TREES AND GRAFTING THEM WITH PEDIGREE BUDS

Needless to remark, to get the best results from the fruit trees, it is essential that the soil be well and abundantly fertilized; and the measure of this plant food increases as the trees wax older and yield more generously. Taking the average price of land in California suitable for citrus culture, together with the cost of planting, irrigating, fertilizing and the care necessary to bring a grove to the age of seven years, the total outlay ranges between $1,000 and $1,500 an acre. The annual expense of properly handling a bearing orchard runs from $200 to $275 an acre. These facts and figures give the consumer some idea of the money which must be spent by the grower in order to get and to maintain his trees in a profitable condition. And now we come to the administrative side of this industry.

PICKING LEMONS, RIPE OR GREEN, WHEN THEY ARE FROM 2¼ TO 2 5/16 INCHES IN DIAMETER, AS DETERMINED BY A MEASURING RING

About thirty years ago, the California orange and lemon business was confronted by a gloomy outlook. Each season the crop increased beyond the ability of the many small distributors to market it successfully. The fruit was carelessly handled, irregularly graded, packed in a haphazard way, and shipped hither and thither to the market without any intelligent and coördinated plan of distribution. The fruit kept badly, markets were alternately over and under supplied, prices to the consumer were high, and the risks were rapidly becoming such as to discourage both merchants and growers. Had this state of affairs continued much longer orchard owners would have had ample reasons for turning their groves over to other purposes, and the nation at large would have been able to obtain but few oranges at any price.

In 1893 the much-perturbed growers held a convention and rationally decided to tackle their marketing problem collectively. Packing houses were built by associations of growers in the different districts where the fruit could be prepared for market and arrangements made to dispose of the product through a central organization. In this way was born the California Fruit Growers Association, which is handling today a tremendous volume of business with greater ease and more success than was possible when the State was shipping yearly only 15,000 carloads of fruit! It is not the purpose of this article to go into the details of this splendid example of collaboration which has virtually revolutionized, through its various activities, well-nigh every department of the cultivation and the sale of oranges and lemons. The farm value of the two staple fruits, so skilfully dispatched that they will always

meet local needs without inviting a glut, reached last year a total of more than a hundred million dollars! And how do these Californians accomplish these amazing results when dealing with decidedly perishable commodities? The answer is by exercising the utmost care at every stage of the manifold operations.

The growers seldom pick their own fruit. This is commonly done by crews composed of people trained to the work who go from grove to grove. Years ago the growers learned that abrasions of the fruit skins permitted the entry of decay spores just as disease germs infect a wound. Accordingly, an orange or lemon must be clipped so as not to cut either the peel or the "button" on the stem end. Neither should the stem be left long enough to puncture the skin of another fruit with which it may come in contact. The picker must remove the fruit from the tree in a way to avoid scratching it on the limbs or branches, and he must place it deliberately in his sack to make sure of not bruising it. Bruising promotes spoiling.

After a picker has filled his sack he next places the fruit in field boxes. This he does by lowering the sack into the box, unbuttoning a flap in the bottom of the bag, and then lifting it cautiously so that the fruit will roll out gently. The field boxes are ingeniously designed to eliminate danger from protruding points and to avoid crushing the fruit. As an added precaution the field boxes are dipped from time to time in a special antiseptic solution to neutralize any lurking harmful germs. All pickers use gloves to prevent their fingernails from cutting the skins; and their clippers are inspected daily to see that they are in proper condition.

When hauling the fruit to the packing houses, the oranges and lemons are loaded on wagons having springs and are covered with tarpaulins to protect them from the sun. At the packing house each grower receives credit for the number of field boxes delivered by his people, and later, when the fruit is graded and sized, he is given a statement showing the number of packed boxes or the number of pounds of each grade and, sometimes, of each size, which he has sent. At most packing houses it is the custom to inspect several field boxes from each load to make sure that the picking has been well done. As each picker places a tag or some designating mark on his field boxes it is possible to locate quickly those responsible for faulty work.

The first operation in the packing house is to clean the fruit, and this is effected by putting the oranges and lemons through washing machines where soft brushes and clean warm water do the trick. The bristles of the revolving brushes are arranged spirally so that they keep the fruit moving onward the while. After leaving the washing machine, the fruit is passed under a cold shower, and then is conveyed automatically into the drier. In their course through the dryer, the oranges or lemons are continually exposed to a strong blast of air, and they thus reach the grading table perfectly dry. From the start of the washing to the exit from the dryer there is an interval of about thirty minutes.

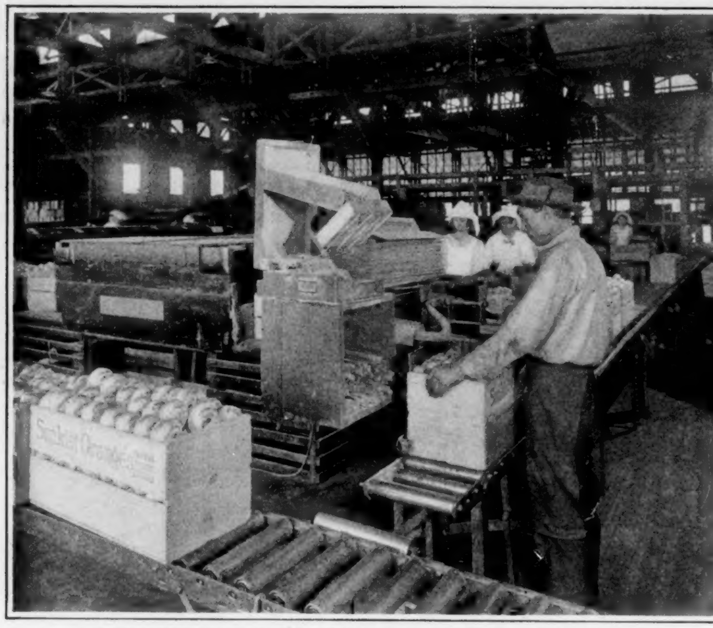
In the case of lemons, which are picked both ripe and green, the "greens" are placed in storage rooms to cure and only the yellow fruit are graded immediately and made ready for shipping. At the grading table all of the oranges or lemons are examined by experienced operatives who assort them according to prescribed standards. This is expert work. The graders stand before an endless belt on which the fruit is carried along, and they pick out the various grades—determined by form, texture, and external appearance—and put them on other belts which take them to their respective bins. Size is not an outstanding factor in this part of the preparatory handling.

From the bins the fruit are fed to automatic weighing machines and thence to sizers which assort them mechanically. The sizer consists fundamentally of a twin arrangement of long rollers, placed slightly out of parallel—the point where the lemons or oranges first come upon them being closer together than the far end. The rollers thus form a tapering and widening runway, and the fruit drop through into bins below when they reach a place between the rollers ample enough to permit this. The rollers keep the fruit in motion, and they turn upward and outward so that there is no tendency to wedge and squeeze the oranges or lemons between them. The bottoms of the bins beneath the sizing machine are of tightly stretched canvas in order that the falling fruit will not be bruised.

Having been sized, the fruit is carefully wrapped and

WASHING LEMONS IN A MECHANICAL WASHER BEFORE SORTING THEM SO AS TO ELIMINATE DISEASE SPORES

SORTING ORANGES ACCORDING TO FORM, SKIN-TEXTURE AND COLOR



PUTTING ON THE COVERS WITH A NAILING MACHINE

ONE OF THE BOX-MAKING MACHINES

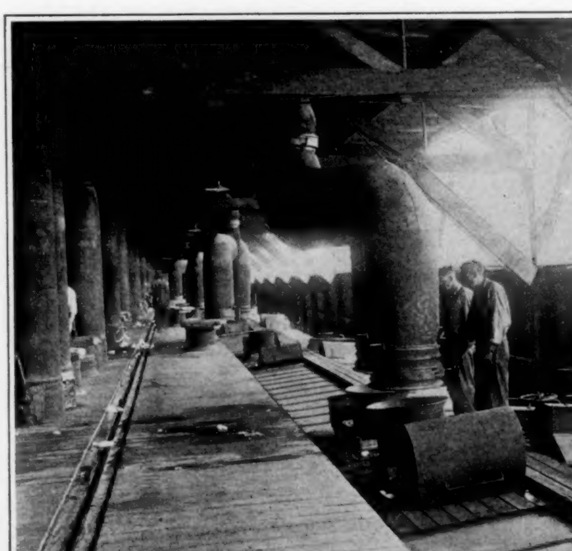
placed in boxes for shipment. The packers are generally women who become remarkably skilful and speedy, being able to pack anywhere from 50 to 75 boxes of average size oranges, for instance, in the course of a working day. Like the graders, the packers wear soft gloves. According to the size of the oranges, a different geometrical arrangement is necessary to get the right number in every box. Thus, a crate of prime fruit may contain 96, 126, 176, 216, etc., oranges. A box of lemons will hold anywhere from 180 to 540.

The crates are made by an ingenious machine; and after packing the covers are secured by a nailing apparatus, great care being exercised in seeing to it that the fruit is neither crushed nor bruised in the process. Next, the filled boxes are piled on the floor of the packing house according to sizes and grades of their contents, and are then ready to go into the iced cars for shipment or into the pre-cooling room before being loaded for transportation. This part of the industry is of prime importance for upon it hinges the successful carriage of fresh fruit for long distances. It should be remembered that the full transcontinental trip requires under normal conditions from 12 to 14 days, and during the run the perishable merchandise are raised a vertical distance of more than two miles—encountering in transit radically different atmospheric conditions. The object of refrigeration is twofold—to delay ripening and to arrest any action tending to decay.

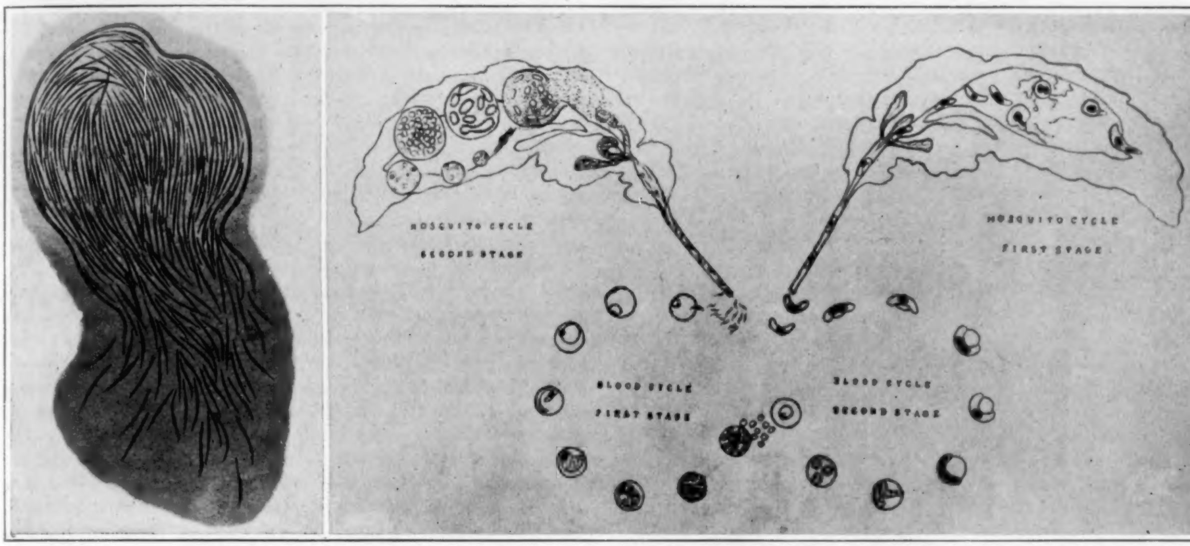
It is not possible in this article to discuss at length the exhaustive research leading up to the present pre-cooling and refrigerating practice employed by the California growers of citrus fruit. There are parts of each year when mere ventilation and the icing of the car will suffice, but there are other seasons when the fruit must be both pre-cooled and refrigerated during its railway journey. The layman may not realize it, but it takes considerable time to cool fruit which is wrapped in paper and tightly packed in boxes. It may require several days to lower the temperature of the fruit sufficiently to retard ripening and decay. It has been found that oranges and lemons can be exposed for several hours, when wrapped and packed, to a direct blast of air many degrees below the freezing point of the fruit without actually inviting freezing; and it is not hard to understand how a snugly filled car will offer difficulty in causing the chilling to thoroughly penetrate all of its contents.

Pre-cooling is generally done by mechanical means, either in a warehouse or cold-storage plant before loading or after the fruit is placed aboard the cars. In the latter case this is accomplished by forcing large volumes of very cold air through the vehicles, thus reducing the temperature of the fruit much more rapidly than by means of ice alone. Pre-cooling may also be effected before packing; and when this is practicable it is comparatively easy, because there is a chance for a better circulation of the air around the fruit. The California pre-cooling plants are big establishments, and are typically up to date in every particular. Pre-cooled fruit may be loaded more closely and heavily, thereby increasing the carrying capacity of the cars and consuming less ice en route.

Such of us as have reveled heretofore in the luscious oranges and lemons of the Far West can now better understand and evaluate the science, the skill, and the commercial acumen which have combined to make our enjoyment possible.



COOLING THE LOADED CARS BY BLOWING IN BLASTS OF COLD AIR



AT THE LEFT, AN OOCYST FROM THE STOMACH WALL OF AN INFECTED MOSQUITO DISCHARGING ITS MALARIA ORGANISMS, THE SPOROZOITES (AFTER SAMBON); *AT THE RIGHT,* THE DEVELOPMENTAL CYCLE OF THE MALARIA PARASITE

The Malaria Parasite

How the Mosquito Actually Carries the Germs of Malaria

By Bruce Mayne

Biologist, United States Public Heatlh Service

SLOWLY yet certainly the cold, calculating forces of science are unearthing or bearing to earth the obscure and invisible parasites of human disease. These are revealing themselves one by one through the relentless though uncanny methods of the investigator who, while bowing to Nature's laws, is no respecter of her hidden truths which must be brought to light to be weighed and analyzed. Science, struggling through superstition and doubt, is carried to defeat in one generation only to come triumphant through the next.

In this manner only recently has come to light the true cause of yellow fever, that awful, devastating malady that is still exacting toll from the unwary, insanitary peoples of the earth. The announcement recently of the discovery of a spiral formed organism associated as the cause of this disease reminds one that yellow fever was conquered only by following the dicta formulated through experimental research with a kindred disease—malaria.

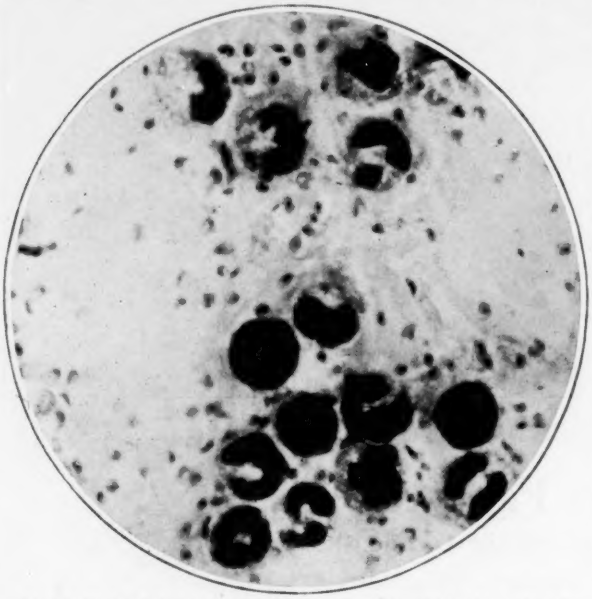
Until the true cause of malarial fever was discovered in 1880 numerous theories on the origin of the disease were promulgated by the medical profession. Among these, the most acceptable was that proposed by an Italian scientist who maintained that a germ named *Bacillus malariae,* which was constantly present in the mud of marshes, was the cause of the disease in man. Other theories, half-baked and fanciful, were proposed in support of the ancient opinion that bad air and bad water were the natural lurking places for the germs which made the human victim shiver and sweat in the paroxysm of the ague. However wrong these views may seem to us now, we must admit that the haunts in which the disease had its origin were known as well as feared by the ancients and that the Italian name for the disease, malaria (*mala-aria*—bad air), holds to this day.

Even so recently as ten years ago certain medical textbooks affirmed, and even unthinking physicians today accept, the notion that drinking polluted water may give one malarial fever. And despite the advances of scientific medicine certain others are still skeptical that the bite of an infected mosquito is the only way whereby the disease can be propagated. One modern author advances the hypothesis that mosquitoes normally feed on plant juices and infect plants by stinging them with the mouth proboscis in the same manner in which the human blood is infected. It is alleged that such vegetable material eaten uncooked would cause in the human host malarial fever through the gastro-intestinal tract. The same medical writer believes it possible to contract the disease in two other ways: namely, drinking water in which malaria-infected mosquitoes have laid their eggs and died, and by breathing air laden with the germs malaria-infected mosquitoes have disseminated.

However, these views have been condemned by the careful student of parasitology and the most modern conception of the problem is bound up in the application of experimental proof. It may be pointed out that in contrast to our skeptics in science many wild tribes in tropical countries have long been observed to protect themselves and their live stock against the bites of mosquitoes, for it was a popular belief that these insects were somehow responsible for the propagation of tropical fevers. Yet the scientific world discredited this belief of the uncivilized man until nearly the beginning of the twentieth century, when the combined observations of the founders of modern tropical medicine had established in all its fascinating detail the fact that the mosquito is the constant and necessary vehicle of malarial infection.

But only recently medical text-books are unanimous in accepting the claims of the modern scientist that the microörganisms harbored by certain mosquitoes have been ingested with the blood from an individual sick with malarial fever. This was announced for the first time fully seventeen years following the determination of the causative parasite in the human blood. The credit for this important discovery is given to Sir Ronald Ross, a British military surgeon, who in 1898 completed his brilliant researches which demonstrated completely the development of the malaria parasite outside of the body of the human host within the mosquito which perpetuated the disease. Ross was able to follow the cycle within the insect until the parasites harbored were in such a developed form as to be suitable to infect new red blood cells when the mosquito bit another human victim.

Abundant proof of this has been furnished from time to time and ample confirmation of the rôle of the mosquito in malaria dissemination supplied through the medium of experimentation. More than sixty well authenticated cases of mosquito inoculation of human volunteers have been recorded. Sixteen of these experiments were conducted in the laboratories of the Federal Health Service under the writer's personal supervision so that the complete story of the part played by the mosquito in the spread of this dread scourge can be told from actual experience.



MASS OF MALARIA ORGANISMS IN A PORTION OF A DROP OF BLOOD MAGNIFIED 1,200 TIMES

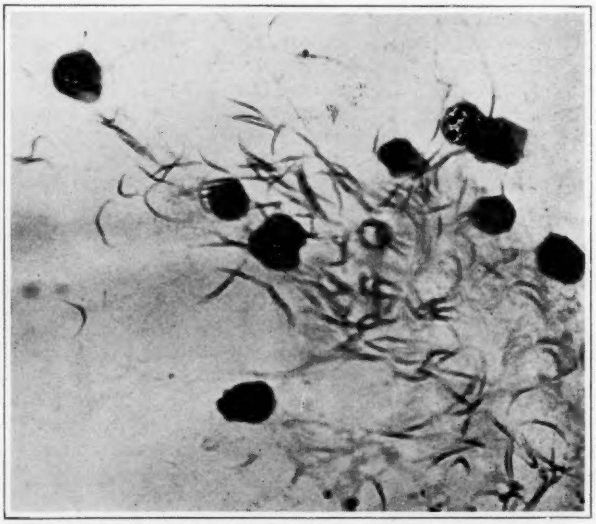
In order intelligently to appreciate the rôle that the mosquito assumes as a vehicle of destruction, it is necessary to describe the condition of the blood in the patient and how he functions as a carrier of these pathogenic organisms. To find these parasites one must examine the blood of a patient suffering from an acute attack of intermittent fever. This is done by drawing on a glass slide a droplet of blood from a finger or the ear lobe pricked with a surgical needle and examining it by means of a fairly powerful microscope. In this connection, when he views for the first time the germs of the disease which have invaded the human blood cells one can appreciate the thrill of the scientific voyager and share the prophetic vision of the discoverer, the French army surgeon, Dr. Alfonse Laveran.

It was a memorable day for Dr. Laveran when, in a French Algerian military hospital, examining with unbounded patience the blood of the victims of the dread scourge of northern Africa he discovered that the cause of malaria was a living organism which destroyed the red blood corpuscles and transformed their contents into toxic substances, giving rise to the classic symptoms of the disease. He had been perplexed a long while in observing one of the minute Amoeba-like specks, which were then believed to be nothing more than degenerated corpuscles, when suddenly the cell projected several long, slender filaments which began to move about very actively, lashing and displacing the surrounding corpuscles. This was accompanied by a peculiar turmoil of the brassy black granules within the cell. Thus was revealed the animate nature of these bodies and was proclaimed the real cause of the febrile disturbance in the patient's blood.

With the discovery of the true cause of malarial fever by Laveran in 1880 the importance of the Protozoa in the field of pathology has never ceased to grow. It was early recognized that the methods of research in the pathogenic Protozoa could not be the same as in bacteriology. These forms have not the same simplicity as the bacteria for in this realm of plant life we know only one single, constant fixed form and the individual organism does not experience a life cycle. With the Protozoa which are associated in human disease the majority go through a cycle in their existence whose successive forms may be very diverse and the transformation may be completed not in a single host, but often in two different ones. Thus it becomes necessary to reconstruct the biology of a parasite common to man and the mosquito.

Now to get back to our personally conducted tour—it may be noticed in our examination of the drop of blood that in a certain number of the red corpuscles there appears a tiny whitish form continually altering its shape much like a gas flame flickering within its glass globe during a gust of wind. These movements of the parasite are called amoeboid because they characterize the movements of the Amoeba, the simplest member of the animal world, consisting of a single cell of living protoplasm. And although it has no constant definite shape, the Amoeba in this instance can assume a threadlike fineness and pierce into a red blood corpuscle as it migrates, after its function of corpuscle annihilation, from cell to cell in the blood stream. Some hours later the parasite in its metamorphosis will have increased in size elaborating minute brassy black grains called pigment granules, the product of the haemoglobin, the substance contained in the red corpuscles which the parasite is constantly engulfing with its jelly like body. These pigment granules gradually become shifted toward the center and help to give the parasite a daisy like appearance when it has finally broken up into a number of segments. When this rosette like arrangement is perfected the red blood corpuscle bursts open like a seed pod and the segments, forming new parasites, escape into the blood stream and are able to penetrate new red cells. Thus the life process is repeated and when the new invader has grown to about the size of the corpuscle and exhausted all its food stuff the partition of the new organism progresses indefinitely as before.

This cycle of development in the parasitic Amoeba, which has taken place wholly within the body of the human host during forty-eight to seventy-two hours, gives rise to definite clinical symptoms of the disease and when at least twenty-five millions of these invaders are present a paroxysm of chills and fever results. After two or more of these paroxysms when several generations have passed during the growth of the invading organisms, an examination of the blood reveals peculiar forms assumed by numbers of the parasites. They appear



SPOROZOITES FROM A LOBE OF THE SALIVARY GLANDS OF AN INFECTED MOSQUITO

as blunt ended crescents with transparent bodies and clumps of black granules in the center. In others, depending on the species of the malaria parasite, these bodies are quite ovoid, resembling the matured forms preceding segmentation. They are now the resting spores or gametes and like the spores of the bacteria, are able to survive in a quiescent state the unfavorable conditions of growth in the living medium.

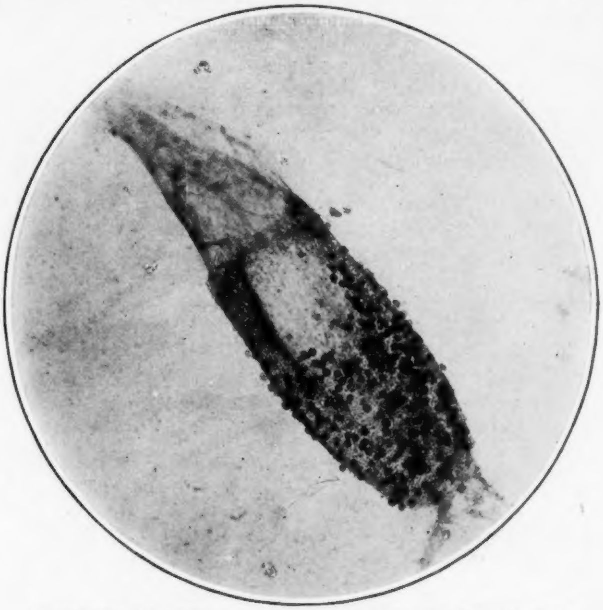
It is now high time for the villain of the piece to enter, for it is during this period of passive life that the gametes require some external vehicle for continued development. This is offered in the ideal form by a preying mosquito which, invading the haunts of man at dusk, chances to draw its fill of blood from a parasitized person. It is necessary for the completion of our story that this mosquito be a female belonging to the genus *Anopheles*, with spotted iridescent wings and long delicate palpi. The protozoan malaria organism seems to have a peculiar affinity for insects of this sort, for thus far no other genus has been found capable of cultivating them. The dormant parasite thus enjoying a change of host suddenly awakes to renewed activity, changes its form from crescent to round throwing out long filaments which leave the body of the cell and are seen to attack organisms of the opposite sex which in natural course of favorable development are penetrated and fertilized. After fertilization, within the stomach of the mosquito the new parasite transforms, becoming more elongated. Then acquiring movement, it is enabled with its spiked end to pierce through the several stomach linings of the insect, finally lodging on the muscular wall of the organ, assuming a globular shape. It soon becomes encysted, though still able to partake of the generous blood supply that accompanied it when it was taken within the gnat's interior.

The cyst now organized becomes enclosed in a structureless, transparent capsule growing to many times its original size. In a fully parasitized *Anopheles* the entire stomach wall appears festooned with tremendous numbers of these tumor-like masses of protoplasm which break up into a number of tiny spheres. Minute spiny processes appear on these segmented spheres which, growing longer separate from their attached cells, appearing as prickly filaments within a sac. Then the membranous sac or capsule bursts and these filamentous, spindle shaped organisms, the sporozoites, stream forth like a school of tadpoles into the body cavity of the mosquito.

NORMAL APPEARANCE OF THE SIX LOBES OF THE SALIVARY GLANDS DISSECTED FROM THE MOSQUITO'S THORAX

It is now a speculation as to the behavior of these bodies, but we know that somehow the sporozoites are carried by the body juices of the insect to its salivary glands, where they establish themselves, mixing with the saliva of the host. When the mosquito bites a healthy person it injects with its saliva a great number of these very active new parasites, the sporozoites which are introduced to begin again the rejuvenated, endless cycle. These sharp ended bits of protoplasm begin the struggling by first penetrating red blood cells, doubling end to end, shaping themselves into rings, each of which develops rapidly into a jelly like Amoeba, the shapeless, active form in which it entered its parasitic career within the blood of the human host.

Thus we have rehearsed a typical biological cycle of ten days



STOMACH DISSECTED FROM A MALARIA INFECTED MOSQUITO SHOWING THE TUMOR LIKE MASSES OF OOCYSTS.
Each round mass is filled with numerous filamentous sporozoites.

with stages of growth characteristic of a disease producing parasite. It would be logical at this juncture to discuss some of the essential factors which retard or accelerate this biological development. And the first that comes to mind, the most influential in the life of any organism, is the factor of temperature. Temperature has both an internal and external influence in association with parasitic life in the mosquito. There is a period which is critical during the time of the fertilization of the human blood parasite in the mosquito's stomach, for it has been learned that this process does not take place if the temperature falls below 60°F. Even should fertilization be successful, the temperature conditions must be favorable until the time of the development of the forms which after leaving the stomach will lodge in the salivary glands and escape through the suctorial mouth.

Finally, the round of parasitism must be completed in the seeking of a human host, the biting of whom must be accomplished at a temperature not much under 65°F. It should be noted in this connection that malarial fever does not exist where the average summer temperature falls below 60°F.; then, too, a temperature between 60° 65°F. must be maintained for the parasite of malaria to develop in the mosquito. It is on this account that the malaria organisms are killed off during the cold days of winter; and although the mosquito lives in a dormant stage, it emerges from its sleep as innocent of carrying disease germs as though it had just emerged from its watery cradle in a preceding stage of life. We must note in passing that it is "man's inhumanity to man" that is alone responsible for perpetuating the disease during the hibernating period, for he is the true winter carrier of malaria parasites; and the finger of scorn must be withheld from the mosquito until the warm days of spring make her again culpable.

To interpret the full significance of the insect's rôle as a

disease carrier, let us get an insight into its powers in ways pathological. How many persons can a single mosquito infect and how many germs is it necessary to inject into one's blood to convey the disease of malaria? Also with the same breath we inquire: How long will a mosquito once infected with these germs remain so? Now, it may be interesting to observe that up to three years ago the conscientious investigator could honestly shrug his shoulders and throw off the burden with "I'm sure I don't know!" but today certain researches have brought to light at least approximate answers to these riddles.

Indeed, all of these points have been investigated, and though not completely solved, have shed rays of hope on prospective researches. Since these queries are concerned intimately with the operation of biting, we can judge more clearly by reviewing briefly the method involved. If one is sufficiently curious and interested and will permit a hungry (though healthy) mosquito to alight on the back of his hand, he can learn enough at one application to be quite convinced. With the aid of a hand lens if one observes the actual blood sucking after the preliminary selection of site for the drilling, it will be apparent that an appreciable time elapses from insertion of the mosquito's beak to the appearance of the drawn blood as it rises in the alimentary tube. The phenomenon is appreciated by the careful surgeon who reverses the operation when in injecting a fluid into the patient's vein he plays safety first, insuring the needle's position by drawing some of the blood into the barrel of the syringe before pressing down the plunger.

THE ARCHER FISH, TOXOTES JACULATOR, SHOOTING ITS PREY [AFTER BREHM]

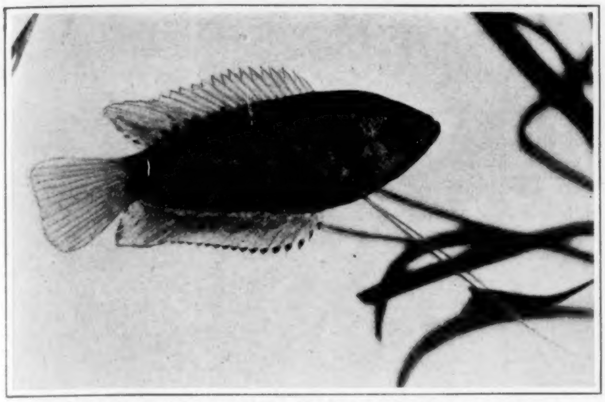
In the first few seconds of biting really all of the mischief is done both as to physical damage to the feelings of the host and the inoculating of the infecting organisms, for it has been proved that mosquitoes inject their poison before commencing to suck blood. This is accomplished by the insect, which in attempting to lubricate the mouth-parts in "clearing for action" deposits its saliva in which are mixed the virulent organisms. Then whether it gets its meal or not, if interrupted at this stage, it has already accomplished its function as a disease bearer by introducing the poisonous fluid into the wound. The pumping of the blood to satisfy the mosquito's nutritive demands is therefore incidental. At any rate, it has been actually proved that when mosquitoes were allowed to bite two volunteers for periods of thirty-five seconds and fifty seconds, illness resulted in both instances, demonstrating beyond a doubt that virulent parasites had been introduced in these short, uninterrupted bites. In the same series of experiments it was demonstrated that several persons, at least three, could be successively infected from the bites of a single mosquito.

Relative to the length of time mosquitoes remain infected it must first be ascertained what is the life of a mosquito. This having been recently determined in our Memphis laboratory to be as long as 185 days, should it prove to be true that an *Anopheles* mosquito can remain infected as long as it lives, a very serious charge can be made against Madam Anopheles—carrying concealed weapons possibly with intent to commit manslaughter. So far, however, experimenters have not been able to cultivate in their laboratories mosquitoes which can communicate the malaria disease germs beyond sixty days and although organisms may be present for four months they appear to be without life.

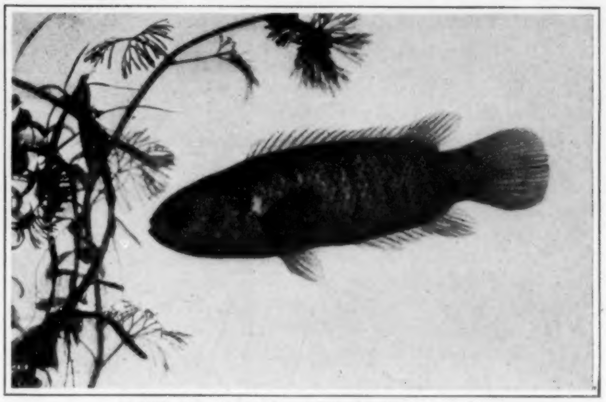
In our review of the mode of carriage of a menacing insect borne disease, we have found that a mere trifle—"a trifle light as air"—has been the cause of it all. Just as a man digs his grave with his teeth it is far more certain that the mosquito's teeth have dug many a grave. And the victory of science in drawing the teeth of the vicious mosquito has blazed the way for scientific control of sanitation and health and has made possible such achievements as the domination of the white man in the tropics.

FISH THAT SHOOT THEIR PREY

ONE of the most curious groups of tropical fishes consists of the *Toxotes* or "archers." There are four species known which inhabit Polynesia and the East Indian Archipelago. The Archer *Sagittarius* is found from the Dutch East Indies as far as the northern shores of Australia. The body is yellowish or olive brown in color, with large rounded or oblong spots or with vertical black bands. The eye is a brilliant pink and the belly a silvery white. The best known species is the *Sagittarius* or *Toxotes jaculator* shown in the accompanying picture. This fish has a singular habit of "shooting" its prey, which consists of the various small insects which frequent aquatic plants or the grass and weeds along the edge of the water, i. e., it launches at them with wonderful accuracy of aim, a tiny jet of water. It is said to be able to project these liquid bullets to a distance of three feet or more and nearly always to hit the mark. The Malays call it the spitting fish. In many countries, says Brehm, it is made a domestic pet by the inhabitants, who keep it in their houses and furnish it with various flies and bugs for the pleasure of observing its marvelous marksmanship. In Java, it is kept in basins over whose surface a small stick extends at a height of about 0.40 meters above the surface of the water. Wooden corks are strung on this stick and insects placed thereon. When the fish catches sight of the hoped-for victim it rises to the surface of the water, remains motionless for a few minutes, and then squirts several drops of water at its prey. It usually succeeds in striking its prey and causing the latter to fall into the water; should it fail it swims about a bit and then tries again.



INDIAN THREAD FISH—TRICHOGASTER LASCIATUS



CLIMBING PERCH—ANABAS SCANDENS

Fish That Can Be Drowned*

Peculiarities of the Climbing Perch and Other Amphibious Fish

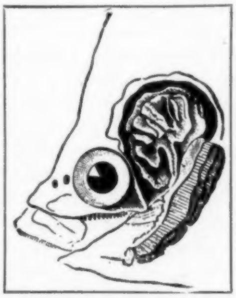
MANY centuries ago a couple of travelers from India's land of miracles related that in the waters which bathe the shores of that land there dwells a remarkable fish, which now and then climbs up the bank, strolls over to a cocoanut tree and climbs its stem to enjoy a bit of palm wine, whereupon (whether intoxicated or not remains a secret!) it returns to its native element. This tale was by no means too big a "fish story" to be accepted in that day and generation, at which period precious little was known of natural history, and there was none too clear an idea of what a fish could do or couldn't do. For that matter even at the beginning of the 18th century a crab was considered a "shell fish" and under that definition the tale will bear the scrutiny of science even today, since as a matter of fact, a certain crab is found upon the islands of the Indian Ocean, the *Birgus Latro*, which actually does steal cocoanuts, climbing the tree to get them and opening them very deftly with its claws.

If this were all we might dismiss the ancient narrative with the idea that it was based upon such a confusion of terms, but early in the 18th century the story bobbed up again, and this time the animal in question was most certainly a fish. The Danish Lieutenant Daldorf reported to the Linnaean Natural History Society of London that he had found a climbing fish in the East Indian coast city, Tranquabar, which had the revolutionary custom of climbing the stem of a palm tree, hooking itself on with the points of the extended gill covers, at the same time pressing the tail fins and anal fins against the bark and thus managing to clamber higher and higher after the manner of our feathered tree climbers. The object of this exhibition of skill was not evident, since there was no pretense of any wine drinking in this case. The story went on to say that the same fish upon being captured played merrily about in the sand for hours at a time, and this statement was the most distinctive feature of the story rather than the climbing and the taste for palm wine.

The members of the London society shook their heads. A fish that so far forgot itself as to leave its proper element and go on picnics was not only absurd, but it was a lucky thing, too, that such conduct was impossible! Fish, they declared, breathe by means of gills and are not able to make use of atmospheric air, but only of air dissolved in the water. . . . Hence Daldorf's story was impossible. In the name of sacred system!

And yet the truth is that the story of the land-going fish is by no means a fable. It climbs, to be sure only in very exceptional cases, and then only upon slanting palm trunks more by chance than as a regular thing, but it is quite true that it regularly climbs out of its pond upon the bank and passes hours in the dry grass with its companions. How can such a thing be possible?

The first to attack the problem boldly was the celebrated French naturalist, Cuvier, in 1831. He examined a pair of climbing fish which had been sent to Europe and found behind the gill cavity a singular pocket-like hollow, within which bony laminæ wound and twisted like branching bits of coral. Cuvier called this remarkable organ the labyrinth, and rightly believed that it was closely connected with the respiratory organs of its owner. Air breathing did not come into the question in his mind since at that time the singular kinds of fish which are intermediate between true fishes and amphibious animals were not yet known to science. He concluded, therefore, that the climbing fish was a water breather like its kin, and designated the newly discovered labyrinth a sort of storehouse for liquids. He supposed that before the fish undertook a promenade upon land it filled this organ with water like a sponge, and then pressed the gill covers closely against its sides in order to prevent evaporation, thus keeping its gills moist and workable. This idea was entirely logical when we consider the limitations of scientific knowledge at that time. Unfortunately, however Cuvier did not hit the facts correctly by this ingenious surmise.



LABYRINTH OF THE CLIMBING PERCH

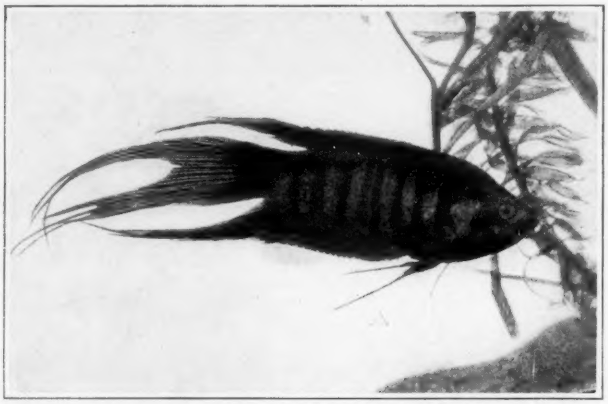
Four years after Cuvier's examination of the climbing fish which he named the *Anabas scandens*, and two years after his death there were found at almost the same time in the swamps of the river Amazon and in the White Nile, those amphibious fish (*Lepidosirus* and *Protopterus*) which temporarily dispense entirely with water and gill breathing, and, thanks to the possession of a true lung, are capable of breathing entirely in air. Everybody was amazed at these new creatures, which in two different ways threatened the beautiful structural system like wicked rebels, but nobody was lucky enough to think of comparing the labyrinth investigation, made by Cuvier with the case of these abnormal double breathers. Investigators for a long time considered the matter settled with regard to the breathing of the Indian climbing fish.

The first man to be attracted by the observations in regard

*Translated from *Reclam's Universum* (Berlin), April 20, 1920.

to amphibious fishes was an English physician named Day, who in 1864 thoroughly examined both the climbing fish *Anabas* and other fin bearers having a labyrinth organ and corroborated Cuvier. The labyrinth pockets were storehouses not for liquids but for air, that was clearly shown by the air bubbles which rose to the surface of the water when the gill covers of the fish were pressed. These pockets are a sort of substitute organs for lungs, by means of which the climbing fish and its relatives are able to lead a life similar to that of the amphibious fish above referred to in Africa and South America. When the native stream of Anagantids dries up the fish composedly make their way across country to find a new watery home, or else bury themselves deep in the moist mud at the bottom. So long as they swim about in the water, however, all of these fish employ their gills for breathing, said Dr. Day.

Once more the matter was settled quite beautifully, only, alas! there was one point where the explanation balked. It was found that when these amphibious fish were placed in a basin of water they behaved exactly like gill-breathing fish in spite of the possession of lungs. But the labyrinth fish, on the contrary, rise to the surface at regular intervals in order to swallow air. Apparently their gills are not capable of providing them with all the oxygen they need. . . . Here then we have a basically new kind of animal deriving sustenance



THE BEAUTIFUL CHINESE PARADISE FISH—POLYACANTHUS OPERCULARIS VAR. VIRIDI-AURATUS

from two mediums, thus forming a parallel to those well-known plants which have their roots in the mud of ponds, while their blossoms dance in the sunlight upon the surface of a little sheet of water.

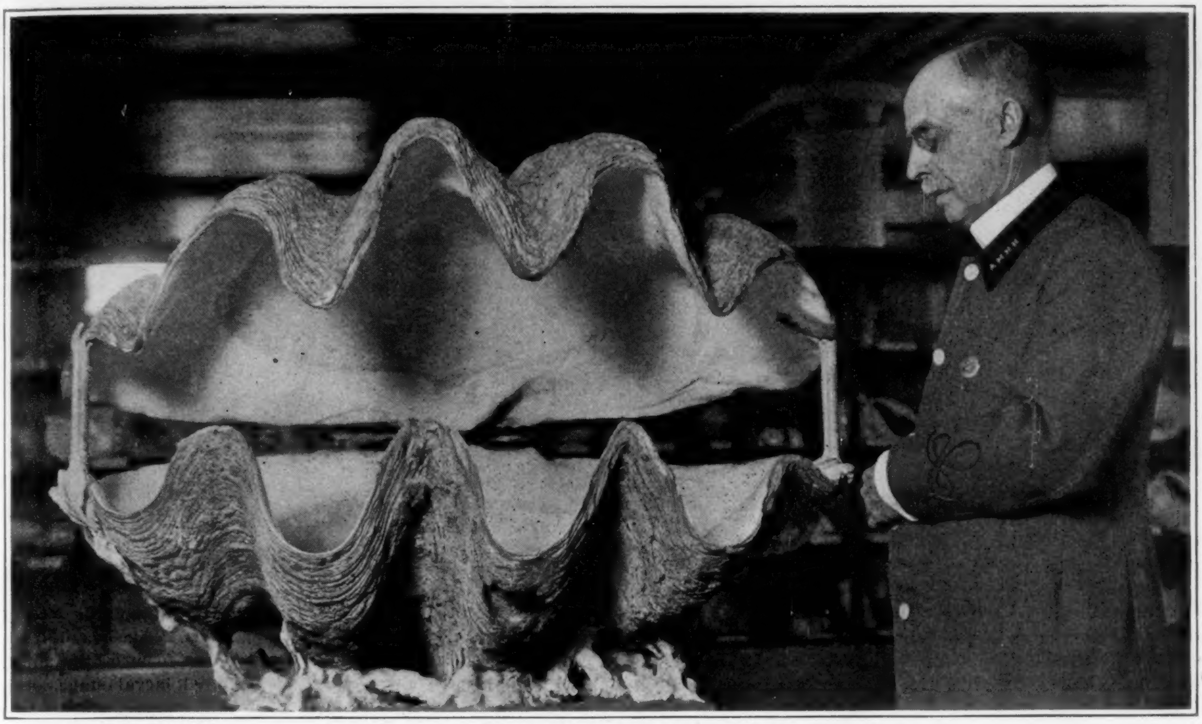
It fell to the lot of a young zoölogist named Henninger to solve the remainder of the problem along these lines. His study included three different kinds of labyrinth fish—the Chinese paradise fish, *Polyacanthus*, the climbing fish, and the Indian thread fish, *Trichogaster*. The paradise fish comes to the surface every three minutes, and the climbing fish every eighteen minutes to attain the required modicum of air; but the thread fish is able to stay under water about one hundred minutes. On every ascent to the surface the animal not only takes in fresh air, but expels the used air from the rear exit of the labyrinth. The gills thereupon move vigorously for a little while, but soon beat very gently and even appear to rest entirely at times. What would happen then if the fish were cut off entirely from the outside air? Suppose for instance that we should spread a net in the aquarium an inch or so below the surface of the water? Henninger did this very thing and with astounding consequences. While the control fishes, minnows, etc., paid no attention to the presence of the net, the paradise fishes showed signs of being greatly disturbed after the end of the second minute. They dashed around the aquarium in the most excited manner, rushing violently at the meshes of the net in an endeavor to break through them and finally sank as if exhausted to the bottom of the vessel. Meanwhile the motions of the gills became more and more rapid, an evidence of increasing difficulty in breathing. Then they convulsively repeated the attempt to break through the net, but obviously with increasing weakness. At the end of half an hour they seemed hardly to be able to maintain their balance, and their upward rushes were ineffective. Then they lost consciousness and turned upon one side and actually perished after a few hours. The poor things were drowned! The climbing fish lasted rather longer and the *trichogaster* lived more than four days, but both of these finally met the same fate as the paradise fish. All of them were finally drowned in the water since they were unable to obtain the atmospheric air they required to supplement the inadequate amount of oxygen obtained through the gills.

NEW VIEWS REGARDING THE "LIVING LARDER" OF THE SPHEX WASPS

SOME months ago the predecessor of this journal the SCIENTIFIC AMERICAN SUPPLEMENT, published an account of the manner in which certain predatory Hymenoptera, including the sphex wasp, provide a supply of fresh food for their larvæ by paralyzing the caterpillar in whose body their eggs are laid. This account was based upon the generally accepted theory of Fabre that these wasps are guided by an infallible instinct which enables them to strike the nerve centers of their prey with a single stroke of the sting. Recent researches upon this subject indicate that the paralytic action is produced not as Fabre thought by a lesion of the nervous system, but by the absorption of the insect's poison into the body of the victim and its diffusion to the nerve centers. Close observation has shown (M. Rabaud, 1916) that the wasp's dart penetrates the body at random and that it is the movements of the victim itself which decide the repeating or the cessation of the stinging, since the wasp continues to use its weapon as long as there is any motion in its prey. In an article published in 1917 in the *Bulletin Biologique de la France et de la Belgique* (Paris) M. Rabaud describes new experiments proving that the paralytic action is due to the diffusion of the wasp's venom. The victim is sometimes merely paralyzed by the action of the poison and is sometimes killed outright; but even in the latter case it remains in good condition for a varying length of time, often as much as from ten to fifteen days or more.

This brings out the interesting point of the double action of the poison—in Rabaud's opinion—namely, a preserving action during the life of the victim by means of a total paralysis due to its neurotoxic properties and, secondly, a *post mortem* preservative action which prevents the rapid decomposition of the caterpillar after death. This preservative effect is found to proceed from a bacterial action due to the presence of the formic acid secreted by the acid glands of the wasp.

Another authority, M. Hollande, in a report to the French Society of Biology, published January, 1920, declares, however, that when the victimized caterpillars are found to be well preserved they are not dead, even though completely inert. M. Hollande took certain small caterpillars which constituted the store of food in the nests of the *Eumenes pomiformis* and made physiological injections in them with coloring solutions of ammonium carminate, carmine-indigo, methylene blue, India ink, etc. In all these cases it was evident that the caterpillars had not been killed by the venom of the insect, even when they appeared to be entirely dead. The proof of this is that their pericardial cells and the leucoytes absorbed the colored powders; the cells of the Malpighian tubes, certain intestinal cells, eliminated the carmine-indigo. Hence in spite of their inertia the cellular life of these caterpillars persists. M. Hollande is of the opinion that the venom acts as an anesthetic upon the caterpillar, causing the latter to enter a state of retarded vitality; in this condition life is maintained as in the hibernating state by the accumulated reserves of nutrition while the cellular ferments of the caterpillar itself prevent it from being attacked by microbes.



Courtesy, Amer. Museum of Nat'l Hist.

SHELL OF A GIANT CLAM FROM THE PHILIPPINE ISLANDS

Humbler Relatives of the Oyster

Clams, Cockles, Scallops, Mussels, Shipworms and Other Bivalve Molluscs

By May Tevis

THE oysters are the aristocrats of the shell fish, and the very king of bivalves, of course, is the pearl oyster. It is the purpose of this article, however, to give an account of some of their less well known relatives which includes the clams of various kinds, the salt and fresh water mussels, the piddocks, the cockles famous in song and story, the curious looking and destructive little creature known as the shipworm from its peculiar long shape, and various other molluscs provided like the oyster with two shells or "valves."

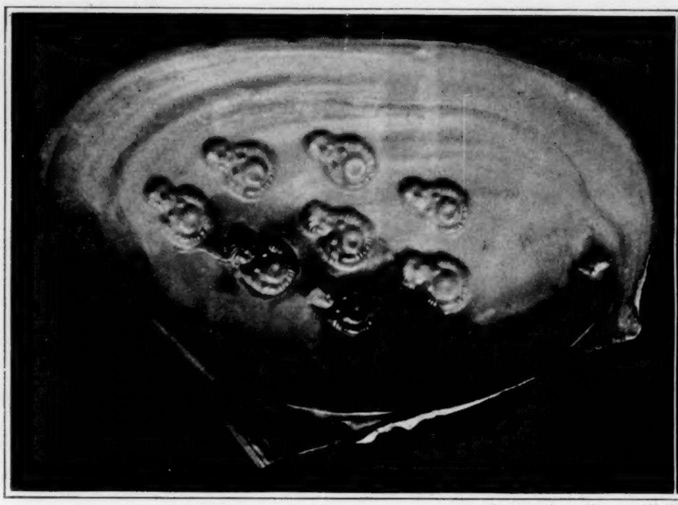
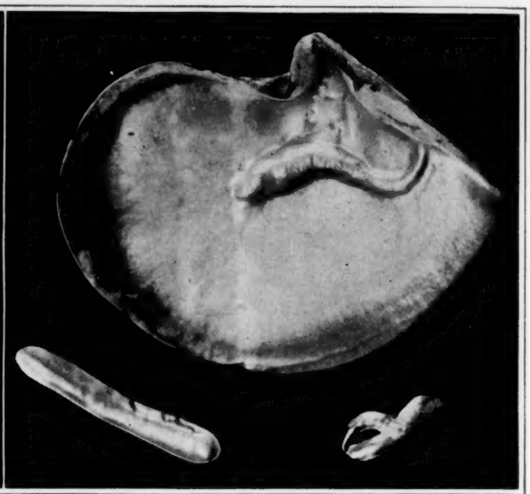
Before giving any specific description of these marine and fresh water animals, most of which are useful to man in one way or another, though one or two are nuisances, it is advisable to let the reader understand clearly their general nature and the characteristics which they possess in common as bivalve molluscs.

THE NATURE AND HABITS OF MOLLUSCS

The Mollusca form one of the principal divisions of the animal kingdom including both land animals and marine animals; the latter having a much wider range than the former. This is easily understood since the land molluscs travel very slowly whereas the marine molluscs, even when not able to swim are liable to be carried far and wide by the action of tides, winds and currents. Some of the marine molluscs such as perwinkles and limpets are found between the limits of high tide and low tide and are, therefore, called littoral forms. Others are found below tide line in the region where seaweed abounds called the laminarian zone, while certain special forms occupy the next or coralline zone. This extends to about fifty fathoms and beyond this we have the deep sea region which is likewise inhabited by certain more or less characteristic species and genera.

There are five principal classes of molluscs, the Cephalopods, the Gastropods, the Amphinerus, the Scaphopods, and the Pelecypods. It is this last class which includes the bivalves with which we are here concerned.

Molluscs are soft, cold-blooded animals, without any internal skeleton; but this is compensated for in the majority of cases by an external hardened shell, which serves at once the purpose of bones and as a means of defence. Their bodies are not divided into segments like those of insects and worms, but are enveloped in a muscular covering or skin, termed the mantle, the special function of which, in the majority of species, is the formation or secretion of the shell. Molluscs are more or less bilaterally symmetrical; but this bilateral symmetry in some cases, particularly among the gastropods, is to a certain extent obscured by the contortion of the body. The foot, which serves the purpose of locomotion, or is used in burrowing sand, wood, and rock, etc., is an organ highly characteristic of most molluses. The shell, in the vast majority, consists either of a single piece, as in the snail, whelk, etc., or of two portions (valves) as in the oyster, cockle, and most other bivalves. In one group, however, (*Chitonidae*), the shell takes the form of a series of eight adjacent plates, and in one group of bivalves (*Pholadidae*) there are one or more accessory pieces in addition to the two principal valves. In the bivalves, with one or two exceptions, the shell is always external. Shells are mainly composed of carbonate of lime, with a small admixture of animal matter. Their microscopic examination has revealed a great diversity of structure. Some are termed porcelaneous, others horny, glassy, nacreous, and fibrous. The shell is essential to the life of the inhabitant, it forms part of its organization, and if it be removed, death follows sooner or later. Although molluscs have the power of repairing injuries to their shells, no case is known of a species removed from its shell having

Courtesy, Amer. Museum of Nat'l Hist.

CRISTARIA PLICATA WITH PEARL-COVERED IMAGES OF BUDDHA

MELEAGRINA MARITIFERA WITH PEARL-COVERED FISH

secreted a fresh one. Many shells exhibit an outer coat of animal matter termed the *periostracum.* It is generally of an olive tint, but varies considerably in thickness and appearance. It is quite smooth, or of a velvety or silky aspect, or it may be produced into hair-like extensions. Its special function is the preservation of the shell from atmospheric and chemical action. Were it not for the periostracum, the shells of fresh-water molluscs would in time be dissolved by the carbonic acid gas with which water is more or less saturated. Owing to the thinness of the periostracum, or to its having been worn away, the apical portion of many fresh water spiral shells and the tips or beaks (umbones) of the bivalves are frequently more or less eroded through this chemical action.

Coloration.—The varied colors of shells are due to glands situated on the margin of the mantle. In most cases the color markings are placed on the outer surface of the shell, beneath the periostracum, but occasionally the inner layer of porcelain-like shells is of a different color from the outer. This is well instanced in the helmet-shells (*Cassis*), which are employed by the carvers of shell-cameos to produce white or rose-tinted sculptures upon a dark ground. The color in some shells is liable to extreme variation. This diversity in color-making results from the different position of the pigment-glands upon the mantle margin, but the cause of this variation in the position is not fully known; nor is the reason known of the difference of the ground-color, which may occur among specimens of the same colony. White, black, red, green, yellow, olive, purple, slate-blue, and brown form the common-ground tints of shells, but pure blue is a color hardly ever met with in the shells of molluscs. One or two species of land-shells (*Corasia*) from the Philippine Islands more nearly approach this tint than any other molluscs, but even in these there is a slight admixture of green. On the contrary, blue is a color more commonly seen in the soft parts. The color of the shell does not necessarily correspond with that of the mollusc. The latter may be of an intense black, the shell being quite white; the "animal" may be a most brilliant creature with a variety of many colors, and its test merely of some uniform sombre hue. Very gorgeously painted shells are, however, generally indicative of highly colored inhabitants.

Reproductive System.—The sexes are distinct in some molluscs, and united in the same individual in others, but reproduction is in all cases effected by means of eggs. These are usually secreted or attached in some suitable position, but in some instances the ova are hatched within the oviduct of the parent, as in the fresh-water pond-snail (*Vivipara*); and probably in most bivalves the eggs are retained within the parent shell until hatched. The productive power of some bivalves is enormous, the ova being counted not by hundreds but by hundreds of thousands, and even millions. The ova of molluscs may be gradually developed into the form of the adult, or there may be a free-swimming ciliated larval stage, or a special larval form as in the fresh-water mussel.

Food.—Molluscs are both vegetable and animal feeders, but probably by far the greater number of gastropods are carnivorous. Bivalves imbibe a mixed diet of infusoria and microscopic vegetables. The carniverous species of gastropods principally attack other kinds of shell-fish, bivalves being especially appreciated. Some, however, like the common whelk, will feed on dead fish and carrion of any description. Many of them are mere cannibals, and attack their own kith and kin. Most land-shells are herbivorous, but a few are carnivorous, preying chiefly on their plant-eating relations, and one curious slug lives exclusively on living earth-worms.

Organs of Sense.—Most molluscs which are provided with a more or less distinct head, namely, the cephalopods and gastropods, are furnished with visual organs, but the majority of bivalves (*Pelecypoda*) are sightless. Although an auditory apparatus exists, they appear almost insensible to sound. It is certain that most forms are endowed with the sense of smell, although the anatomist frequently has difficulty in discovering the position of the olfactory organ. Land-molluscs appear to recognize their proper vegetable food by the smell as well as the taste, and the carrion-feeding whelks are probably attracted by odor. The senses of smell and taste are probably but imperfectly developed in the bivalves, which scarcely possess the power of selection as regards their food.

Locomotion.—Molluscs exhibit various ways of progression. Some are free-swimmers, like the cuttle-fishes, and a few bivalves; others are mere crawlers, like snails and whelks; and some creep along, but beneath the surface of the water. The *Melampus* moves onward after the fashion of a looper-caterpillar, and the bivalves either crawl upon their feet or progress by a perking or leaping movement. Many species, like the limpet, *Saxicava*, and *Pholas*, are very sedentary in their habits, and others, which in their early career are active, in after life are stationary in their permanent abodes.

Uses in Nature and to Man.—Molluscs form a large item in the food of many mammals, birds, reptiles, and fishes. Terrestrial forms are devoured by rats, ducks, thrushes and other birds; by lizards, toads, snakes, and even by certain kinds of carnivorous insects. The fresh-water forms are consumed in vast quantities by water-birds of every description, by fishes, frogs, water-voles, and other mammals, and aquatic creatures of various kinds; and every seashore is constantly ransacked by flocks of sea-fowl for the repasts of shell-fish it affords.

In the depths of the ocean many kinds of fish, especially cod, haddock, gurnard, soles, and mullet, are greedy for molluscs, crabs, starfish and anemones.

Molluscs of all kinds, but especially the marine species, are widely used as food by man; and even in Europe, although the oyster is the most liked, several other species are used as food.

Noxious Molluscs.—The utility of the molluscs to man probably far outweighs the injury which is occasioned by a few kinds, says a writer in the Royal National History. "In the foremost rank of the injurious species stands the *Teredo*, the great destroyer of submerged timber. The stone-work of breakwaters occasionally becomes more or less damaged by the burrowing habits of the *Pholas* and *Saxicava*. On land, snails and slugs commit onslaughts upon our crops and gardens, but these pests are more easily overcome than their marine relatives."

GENERAL CHARACTERISTICS OF BIVALVES

The bivalves have certain special features which differentiate them from other molluscs, the most characteristic being the lack of a head, the bilateral symmetry and the double-valved shell. The mantle is divided into right and left lobes forming a flap on each side of the body to which it is united at the upper part under the line of the hinge. The mantle is generally very thin except at the edges which are sometimes double or triple. In some genera the edges of the two lobes are free or unattached at any point excepting at the dorsal attachment while in others they are joined at one or more places leaving orifices through which the foot can be extended in front, for the admission of the water to the gills, and for the elimination of waste matter at the rear end. At this rear end the mantle is often considerably extended forming one or two distinct tubes known as siphons. These vary greatly in length in different groups, occasionally being several times as long as the shell. The most remarkable example of this prolongation of the siphon is in the case of the *Teredo* or shipworm, whence the popular name of the animal.

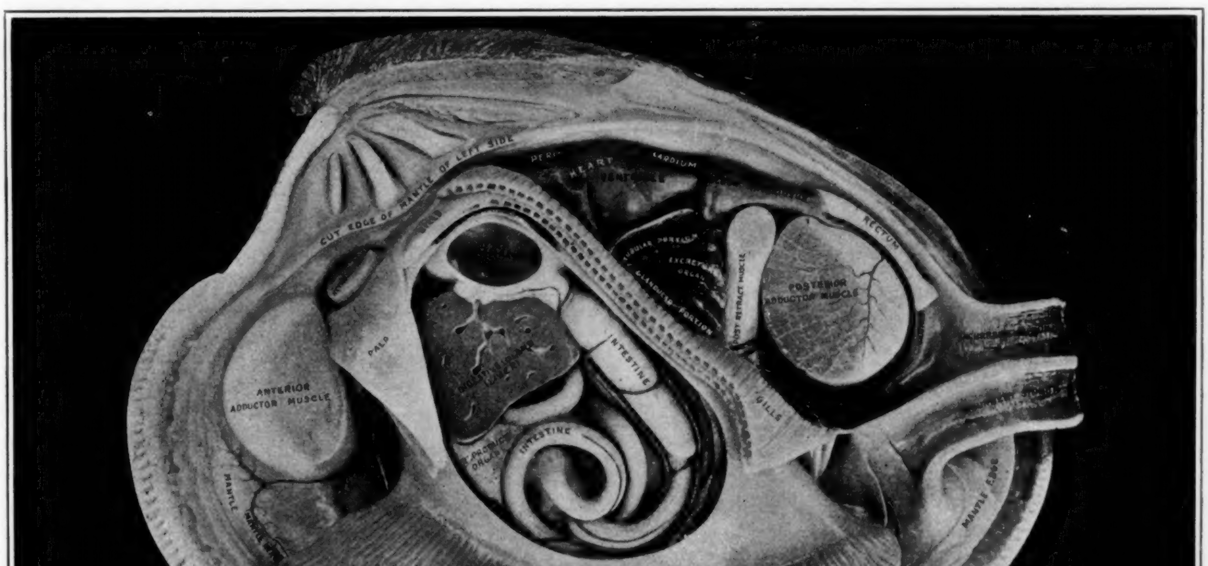
The Foot.—While the shipworm is nearly all siphon some of his brother bivalves are nearly all foot. In the razor shell clam, for example, the foot is enormously developed. This so-called foot is an extremely useful member and is used for the most various purposes—as a means of locomotion, for burrowing in sand or mud or for perforating rocks, wood, etc.; consequently it is very various in form among the different bivalves.

The Mouth.—This is situated at the forward end of the body at the upper front part of the foot and is a mere slit. The upper and lower lips are usually prolonged to form two lobes known as labial palpi.

The Gills.—The gills, which are leaf-shaped, are arranged on each side of the body and enclosed by the mantle. The gills and the inner surface of the mantle-cavity are covered with microscopic cilia. The vibration of these cilia produces the currents required for respiration. After the water has been filtered through the gill it passes out through the anal opening.

The Nervous System.—This consists of three pairs of ganglia; the cerebral pair is usually located above the oesophagus, the pedal pair in the foot, and the other pair in front of or under the posterior adductor muscle. Most bivalves possess the senses of touch, smell and hearing, and some even have eyes. When eyes are present they are found either on the edges of the mantle or at the end of the siphons, and in some forms they are highly developed.

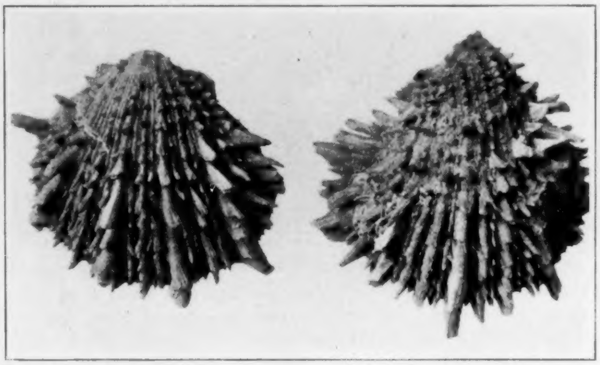
The Shell.—The two halves of the shell, which correspond to the two lobes of the mantle are generally of equal size and shape. They are nearly always joined together at the back by an elastic ligament called the *resilium*, and they are often closely interlocked at the same point by projections on the edge of the valve known as hinge-teeth. In most species the valves shut together closely at the edges, as in the case of clams, mussels, cockles, and oysters; in some, however, they gape apart at one or both ends or at the ventral side. The lining of the shell varies considerably, being sometimes thin,



Courtesy, Amer. Museum of Nat'l Hist. ANATOMICAL STRUCTURE OF THE COMMON CLAM, VENUS MERCENARIA

smooth, and glossy, while at others it may be thick, velvety, rough or shaggy. Sometimes it is pale yellow or olive in color.

The Abductor Muscle.—The tightness with which bivalves are able to keep the two halves of their shells firmly united is a matter of common remark, and is responsible indeed for various proverbial expressions, such "mum as an oyster," "he shut up like a clam." This closure is effected by very powerful muscles known as adductor muscles, there being sometimes one and sometimes two present. These muscles, which are firmly attached to the inner surface of these valves,



Courtesy, Amer. Museum of Nat'l Hist.

SPONDILUS PICTORUM FOUND ON THE WEST COAST OF AMERICA FROM THE GULF OF CALIFORNIA TO PERU

have such an enormous energy of contraction that it is impossible to force the shell open without actual violence.

Dwelling Places.—All the bivalves live in water, most of them in the sea, where they are found at all depths, though they mostly abound in shallow water. Some of them live buried in sand or mud like the familiar "soft clam" of our northeast coast and the pretty little rainbow clam of Florida. Others are attached to rocks, etc., either by the shells themselves or by means of an appendage known as a *byssus*, which consist of horny fibers secreted by a gland near the end of the foot. Others still bore into rocks, wood, and other substances, while a few take up their abode in sponges, in the grooves of sea urchins or in the shells of certain Tunicata; while one species is a parasite living inside the little animal known as a sea-cucumber.

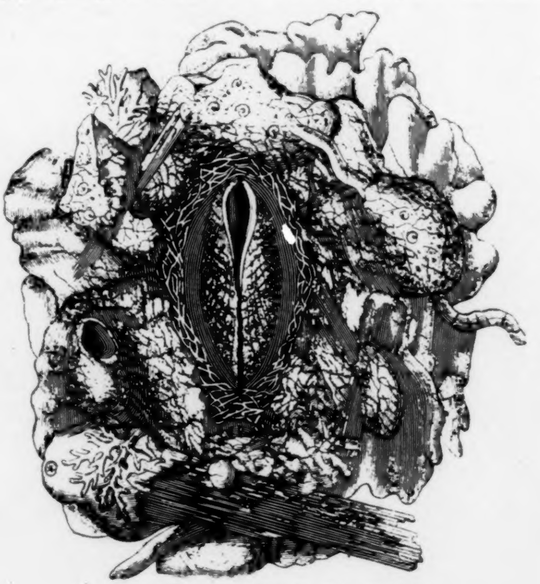
Regeneration of Destroyed Parts.—One curious and truly enviable faculty possessed by many molluscs is the power of replacing portions of the body which have been lost through accident or otherwise. We use the word otherwise advisedly since Gray and Couinard relate the remarkable habit of one genus of the Harp bivalves of detaching of their own free will the posterior portion of the ventral sole or bottom of the body by means of repeated contractions. In many cases molluscs grow new tenacles, portions of the foot, etc., after a lapse of time which varies according to the time of the year.

General Uses and Commercial Importance of Molluscs.—Mankind has made use of the flesh of molluscs since the dawn of time and of their shells for various purposes, particularly of adornment. Thus, necklaces of attractive looking shells, whose name is legion, are popular among various savage tribes not to mention civilized nations. An enormous industry has been built up in modern times in the making of so-called pearl buttons from the mussel shell. In some parts of this and other countries clam shells or scallop shells are much admired in the form of borders for flower beds and rustic walks. In many cases shells have been used as money, thus the cowrie, a smooth and shining little shell, is current coin in Siam and some parts of Africa, and the shell money or wampum of the Red Indians is well known. The art of making shell cameos is an old one and some of the work thus produced is very beautiful. Of course, however, the richest ornaments for which we are indebted to the molluscs are the pearls which are found not only in the oyster but less frequently in the mussel and even in the clam.

CLAMS OF VARIOUS SORTS

The name clam is applied to a number of bivalves of somewhat similar nature. The one used for making chowder is the hard clam which rests at the bottom of the water without burrowing in sand or attaching itself. This is the *Venerea mercenarea.* This is found all over the world and is a typical bivalve; it is sometimes called the Quahag or the Little Neck. The soft clam lives in the sand and when it is present it may be discovered by the tiny jets of water which it squirts up through the sand. Thus the very precaution which the timid creature takes of retiring into its shell when startled by a footfall above it betrays its existence to the enemy, since in order to close its shell it is necessary to eject the water from its siphon. A very beautiful clam, and one of delicious flavor, is one found on the east coast of Florida, and commonly called there the Rainbow Clam. The writer has often scooped them up in handfuls. These shells which are somewhat elongated horizontally are hardly larger than one's finger nail. While mainly white in color they are touched with delicate shades of yellow, pink, and green, so that they resemble a mass of sweet pea blossoms. These are not generally used in chowder, though the meat is delicious, because the job of picking them out is too tedious. However, they make an extremely appetizing clam broth, far more delicate in flavor than the somewhat strong tasting Little Neck. Space forbids us to give a detailed description of the various clams known to fame, but the very names of many of them suggest their aspect. Thus there is the bloody clam, so-called because unlike most shell fish it has red blood. Others are the Blue Point, the Bear's Paw, the Broad Tooth, the Deer Horn, the Nigger Head, the Furbelowed Clam, etc. Of these Reed says:

"The *Tridacnae* or Furbelowed Clams, one of which, T. *gigas*, is the largest of all molluscs, live in beds of some extent in lagunes among coral reefs, among the islands of the Eastern and Pacific Seas. The shell is generally white, sometimes tinged with red and saffron or brown yellow, but the animal



A LIMA IN A NEST IT HAS BUILT

is brilliantly colored. M. Quoy describes the beautiful iridescent glare of blue, violet, and yellow, variegated with fantastic markings, that is presented by these submarine parterres as seen through the clear blue water; and Mr. Cuming speaks with enthusiasm of passing over a mass of them nearly a mile in extent, which resembled nothing so much as a beautiful bed of tulips."

The Giant *Tridacna* (T. *gigas*, Lam.), attains the enormous weight of six to seven hundred pounds, measuring two to three feet across. One sees the single valves used to contain holy water at the doors of Catholic churches. The animals habiting these gigantic shells weigh upward of twenty-five pounds, and are described as very good to eat. The natives of the Caroline Islands hew axe heads out of the thickest portions of these shells, whose hardness is remarkable. "So far has the process of calcification proceeded that scarcely a trace of animal matter remains in an adult shell. Out of the open lunule (the depression in front of the hinge), the foot projects and from the gland a powerful tendonous byssal cord is spun. By this the mollusk is anchored to coral rocks.

The California Sunset Shell is another attractive clam, pleasantly described in the following manner by a recent writer:

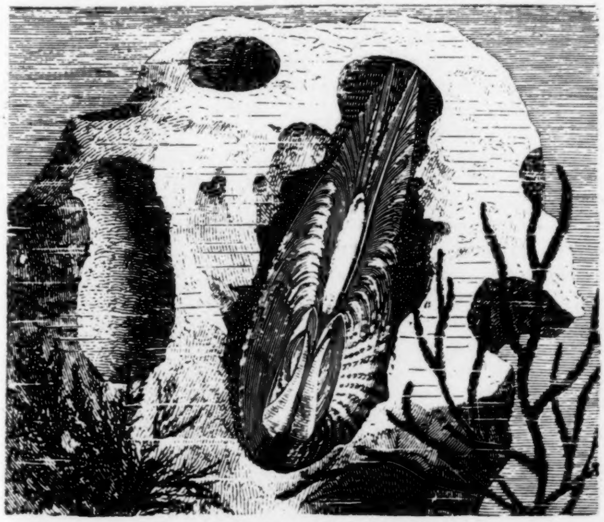
"While returning one morning from a ramble over the rocks of Pacific Grove that had been left bare by the retreating tide, I was much surprised to see what seemed to be two white worms moving about in a little hollow between the mossy rocks, which was filled with sand and seawater. They were long and round, and about the size of a lead pencil. As soon as I disturbed them a little, they disappeared beneath the surface of the wet sand. Suspecting what these singular creatures might belong to, I at once began to dig, and soon came upon a fine clam.

"I was exceedingly glad to make the acquaintance of a real, live *Psammobia californica*, Conr., the California Sunset Shell, for so I learned to call him. As I wanted to see more of him and become better acquainted, I took him home in a large glass jar, filled with sea-water and sand, and had the pleasure of seeing him dig a burrow and throw out his beautiful siphons. I kept him thus for several days, but he could not live comfortably in my very limited "ocean," and when he had ceased to live at all I prepared his shells for my cabinet, where they remain to this day.

"Within they are the purest white, resembling fine porcelain. The pallial sinus is large, the hinge-teeth small, and behind them is a thickened portion of shell about half an inch long, which terminates quite abruptly, exposing part of the ligament. Externally it is white, with red rays running from the umbones, while the newer parts are covered with a brown epidermis."

COCKLES AND SCALLOPS

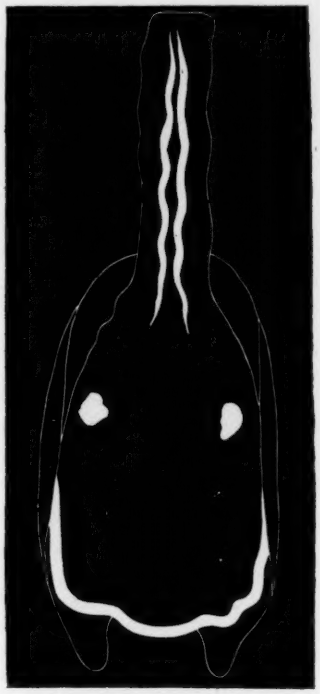
The cockles are sometimes called heart shells from the shape of the valve which reminds one of the ancient expres-



ADULT PHOLAS IN ITS ROCK BURROW

sion applied to good wine or to good fellowship, "it warms the cockles of one's heart." This genus contains 100 species distributed throughout the whole world in sand or mud near low water, and forming large beds in sheltered inlets or bays. The edible cockle is one of the most popular shell fish in Europe, whether for food or for bait.

THE TEREDO AND (AT THE RIGHT) ITS SAND TUBE



NIGHT VIEW OF A PHOSPHORESCENT PHOLAS

The scallops are a very beautiful shell of world wide distribution and include 200 species. The shell is ribbed with ear-like extensions of the hinge line, the mantle is open, with a double border of fringed tenacles and a row of conspicuous eyes, but with no siphons. The adductor muscle of the scallops is eaten and it forms a favorite delicacy both in this country and abroad. The byssus, the cord by which the scallop attaches itself, is formed by a glutinous secretion of the byssal gland. This secretion issues through small pores forming delicate threads which the scallop manipulates by means of its foot, which is in fact not unlike a finger in its mode of action, to form a rope which is toughened by the action of the salt water. Young scallops are all able to spin these cobweb-like threads at pleasure; by means of it they fasten themselves as by an anchor line to rocks, sticks, or other objects on the bottom of the sea, casting off the line when they wish to move along. Most adult scallops abandon the use of the byssus. The aspect of the living scallop is thus charmingly described by Julia Ellen Rogers in her well-known volume *The Shell Book:*

"No creature that lives in the vasty deep can be prettier than these daintily sculptured, gaily painted shells, full of life and grace of motion, sometimes trailing behind them plumes of seaweed. Look when the opening lips show the fringed mantle margins. They are as brilliantly colored as the shell. A row of bright eyes heads the fringe. Each eye is an iridescent green spot, encircled by a rim of turquoise blue. Some authorities doubt that these eye spots are more than phosphorescent illuminating organs. Yet they have the cornea, lens, choroid coat and optic nerve. Dr. Cooke calls them *bona fide* eyes, approximately more closely to vertebrate eyes than any other found among bivalve molluscs."

Belonging to this same family of the *Pectinidae* is a most interesting little creature called the gaping Lima or *Lima hians*, a native of European seas. This shell fish makes for itself dainty and picturesque nests not unlike birds' nests in appearance, fastening together by means of its byssus threads

tiny stones, bits of shell or coral, sticks, etc. After forming this retreat the little creature lines it with a soft and delicate tissue, reminding one of the down with which many birds line their nests. This shelter is a very effective protection against the enemies of the Lima and is all the more necessary because the valves do not fit closely as in the case of a clam or scallop, but gape apart as shown in the accompanying illustration. The shell is of a dazzling white color and from the openings at its two ends there issues a fringe of orange colored streamers belonging to the mantle, trailing behind when the animal moves like the flaming tail of a comet. O. Schmidt tells us that the *Lima* moves by a series of vigorous jerks by means of violently opening and closing its valves. These movements are so violent indeed that by means of them some of the beautiful orange streamers become detached, which, however, according to Schmidt, seems merely to impart fresh vigor to the animal's vitality.

SALT AND FRESH WATER MUSSELS

The edible mussel is more popular in Europe than in this country where clams and oysters are considered more appetizing. The fresh water or river mussel is of importance not from its food value but from the beautiful nacre which lines its shell, and which has caused it to become the raw material of the lucrative business of pearl button making. Very beautiful pearls are somtimes found in this mussel.

BIVALVES THAT BORE INTO WOOD AND ROCK

The Shipworm.—One of the most singular of all bivalves is the *Teredo navalis*, the much-dreaded shipworm, which has destroyed millions of dollars' worth of property in ship bottoms, wharves, and piles, all over the world. This animal has a most remarkable life history. When first born it lives for a very brief time in the free swimming state, during which time it possesses eyes which it later loses. When the baby borer is about as big as the head of a pin, however, it proceeds to settle itself in life by making a burrow in submerged timber. It begins to burrow inside, cutting off fine chips with the foot and possibly also with the valves. The valves in fact are said by the well known authority, Mr. Miner, of the American Natural History Museum, to have ridged edges like a file and thus form an excellent cutting instrument. As the creature digs himself in the burrow gradually increases both in diameter and in length, the ends of the siphon being always at the small exit while the valves of the shell are at the far end of the hole. The fine chips are swallowed and thrown out of the excretory siphon, while a steady stream of water containing fresh air for the gills passes into the entrance siphon. The waving cilia at the end of this siphon also drive in minute organisms, infusoria, etc. The particles of wood seem to be merely compressed and not digested. The shipworm breeds in the spring and it is said that a single female produces millions of eggs. Many methods have been tried to check the inroads of this devastating creature; the ones finally found the best being applications of creosote and metal sheathing.

The Piddocks.—The piddocks also make burrows not merely in wood but in rock or clay. The siphons are large, long and united except near the ciliated edge. One of the best known is the genus Pholas; all of these have the property of being phosphorescent. Like the shipworm the pholas spends its care-free infancy swimming gaily about, but soon settles down to hard work in digging a cell in rock, clay, or wood. Some of them even burrow into granite. The burrow is made by the constant revolution of the shell so that its hard, rasping surface grinds off the inner wall of the burrow, the foot holding tight to the support by means of suction. When making its first attack particles of sand are grasped by the foot and rubbed against the rock so as to form an abrasion. Once installed the piddock is as safe and comfortable as a cave man. He is even better off in fact, since he does not have to make occasional forays for food. His principal enemies are the starfish and crustaceans which delight in nipping off the ends of his siphons before he can draw them out of the way. One of the most beautiful of the piddocks is found in colonies about a foot deep in sandy mud in Florida; this shell is known as Angel's Wings, from the striking beauty of the color, outline, and modeling, which closely resemble the conventional wing of an angel. These are seven or eight inches long. It is sometimes called the ribbed pholas and is a valued food in Havana.

CAUSES OF ALTERATIONS IN CANNED GOODS

THE alterations which sometimes occur in canned or preserved meats, fruits and vegetables are due in some cases to physical causes and in others to those of a chemical nature. The chief physical causes consist in a deficiency or an excess of heat, the former producing incomplete sterilization, whereas an elevated temperature which is too high or too prolonged may unfavorably affect food in other ways. The chemical causes are much more various in nature. They have been recently examined and described by M. Nippegen in the October number of the *Industrie Française de la Conserve*, from which we quote the following summary:

In some cases of fish as well as of vegetables the alteration found may be ascribed to the materials employed to preserve them. This is the case when the vegetable oils which are used contain traces of mineral oil . . . sometimes, too, the goods are contaminated during the process of preserving by oil from the machines employed, thus receiving a disagreeable taste and odor. The taste and odor are likewise unfavorably affected at times in the case of goods brought to a high temperature after being placed in the cans, by reason of the fact that the sides of the can are acted upon chemically by the contents. This defect can be remedied by a double treatment. In the first treatment the goods are subjected to a temperature which is lower than that required when they are sterilized in a single operation. After this first treatment a sufficient length of time is allowed to elapse to develop the spores of any bacteria which may be present. These are then destroyed by subjecting the contents of the can to a temperature of 180°F. for a suitable length of time.

Another cause of alteration in canned goods is due to the action of the acids contained in certain fruits and vegetables upon the tin coating of the containers. This action may be intensified by the presence of traces of other metals which occasion an electrolytic action. This defect can be prevented by treating the contents of the can with some substance which will neutralize the acidity such as bicarbonate of soda, and then eliminating the salts formed by washing.

Sometimes the color of canned goods undergoes alteration; this is generally due to the presence of iron, but may also be caused by zinc, lead, or copper, as well as by the character of the water employed; for this reason it is important to ascertain the chemical nature of the latter. A peculiar kind of discoloration is sometimes caused by the zinc employed in soldering the cans. Whenever this occurs the goods are spoiled and should be condemned.

Sometimes the cans are piled up without having been previously properly cooled. In this case the heat retained frequently causes discoloration.

Green peas which have not been carefully cooled by means of cold water after being put up, nearly always exhibit a turbid liquor. The reason for this is that the starch contained in the peas, which has been set free by cooking, is absorbed by the liquid.

REFLECTING POWER OF STELLITE AND LACQUERED SILVER

EXPERIMENTS by W. W. Coblentz and H. Kahler on the reflectivity of stellite show that it varies somewhat in the visible spectrum depending upon the homogeneity and doubtless upon the exact composition of the alloy. Lacquered silver mirrors exposed to ultra-violet light turned brown owing to photochemical action on the silver thus reducing the reflecting power.—Bureau of Standards, Bulletin 15.

The Education of Chemists

Influence of Mathematical Speculations on the Progress of Chemistry

By Henry Le Chatelier

THE somewhat special topic, which I propose to discuss with you, is connected with a much more general problem, that of the education of chemists. In starting this debate on the part played by mathematics, it has been my intention to argue against the method of highly specialized training in vogue in the schools of chemistry. In my estimation, the head of a laboratory must possess a general scientific culture in order to make an efficient operating man in the factory. The substance of this training is not exclusively chemical, nor physical or mechanical. It must possess at one and the same time all these properties of a most varied nature and it is equally necessary to study them in all their phases.

In fact, the most important industrial laboratories are generally directed by engineers, graduates of the large schools, and not by men who are chemists by profession. It is only necessary to mention the names of Osmond, Deshayes, Charpy, Guillet, Bied, Taffenel, all former students at the École Polytechnique, Centrale or Mines to prove our contention. In spite of the inadequacy of their experimental training, they have done good work, because of their more thorough scientific education. But chemists who would join a very good scientific training to their extended laboratory experience would undoubtedly be able to render even better service. We must, therefore, have a higher or graduate school of chemistry, similar to the graduate school of electricity, where the students of the large universities and graduates from the technical colleges could acquire further training in the practical application of the methods of experimentation and research organization of the scientific staff.

A second problem, that of the organization of the scientific staff in the factory, is connected with the one of the education of chemists. Such an organization does not exist at present. The law of the division of labor, which is today the absolute rule in all factories, is still unrecognized in laboratories. The chemist, just like the ancient artisan, is considered to be a "jack of all trades." He is at one and the same time head of the office, manipulator, that is, analyst and research chemist and even ordinary laborer. It is impossible to combine in his training all the phases of his disparate duties and give him an equally adequate instruction in each. It is, however, comparatively easy to devise an organization, well-suited to the work on hand and a personnel, corresponding to that division.

RÔLE OF THE GENERAL MANAGER

The chief chemist of the laboratory must necessarily be subordinate to the general manager or in very large establishments to the superintendent of manufacture or the technical director, who is responsible for the utilization of the results obtained by the laboratory, who regulates its activities and sends to it for investigation and research the various problems arising in manufacture. The education of these engineers or technical directors is the concern of the large technical schools.

RÔLE OF THE CHEMICAL LABORATORY

At the head of the laboratory itself, there is found the chief chemist who is responsible for preparing and directing the work. He institutes the experimental methods, appropriate to the solution of each problem; he divides the work between his various assistants; he controls the accuracy established in the research and interprets its results. The education of chief chemists is not conducted in the proper manner at the present time.

The greater part of the active staff of the laboratory may be formed of experimental or research chemists and physicists, who may be more or less specialists in their lines. Their work may then be allotted to them according to their particular qualifications. Their education is carried out at the present time in a satisfactory manner by the various schools and colleges.

Finally, for routine manipulators, which are repeated each day in an exactly similar manner, as chemical analyses and measures of all kinds used in the control of manufacture, ordinary workers, women or girl operators, whose training can be very rapid, may be used.

It is my intention today to demonstrate that the chief chemists require a rather well-developed mathematical training, comparable at least with the program of special mathematical courses in colleges or of general mathematics in universities.

USEFULNESS OF HIGHER MATHEMATICS

That a chemist should have a knowledge of the four rules of arithmetic, simple and decimal fractions, that is, the essentials of primary mathematics, no one would, to be sure, deny. There could be no gravimetric analysis without additions, subtractions, multiplications and divisions; no volumetric analysis without the rule of proportions, without the solution of problems according to the rule of three (solution of a proportion in which three of the terms are known). But does that suffice? Can this elementary instruction be given advantageously in chemical schools? The answer is often in the affirmative. Geometry and algebra would be valueless. But has there ever been a chemist who has never had the occasion to draw a curve to show the variation in any phenomenon, the changes in the solubility of a salt, for example, or again to calculate an interpolation formula so as to group together experimental results? Does not that require a thorough study of curves and algebraic functions? Can we be really satisfied with instinctive knowledge in the place of elementary geometrical principles? Let us examine the results that we would obtain by this method.

IMPORTANCE OF THE IDEA OF CONTINUITY

Many chemists are ignorant of the conception of continuity, which the study of mathematics on the contrary develops. When I was still in college, we were taught that there is a maximum solubility of certain salts and we were always given the example of sodium sulphate. The curve, that we were shown did not, however, have any maximum, but a point of rest, which is absolutely different.

All the phenomena in nature are subject to the law of continuity. The curve was evidently wrong. Having had occasion at a later date, in the course of my own researches, to read Loewel's article from which the study of the solubility of sodium sulphate was taken, I was very much surprised to find that Loewel never uttered any of the absurdities that were ascribed to him. His results had been changed to correspond to the standard of the text books by chemists who had absolutely no knowledge whatever of the properties of geometrical curves. Loewel had, however, established a new and very important fact: the existence of separate and distinct solubility curves for each variety or different hydrates of the same salt.

These curves intersect at certain points, as is natural, without being in any wise limited by their point of intersection. This ignorance of mathematics has retarded the progress of our knowledge of the solubility of salts for twenty-five years.

We have another analogous example. An eminent savant spent several years in research to establish the fact that the

*Address delivered before the March Meeting of the Société de Chimie Industrielle of France.

solubility curves of salts are composed of segments of straight lines joined to arcs of the circle. He undoubtedly did not known that the abrupt change in the radius of curvature constituted a true discontinuity and was consequently from its very nature, an impossible means of representing an actual phenomenon. Naturally, nothing ever developed from his work, whose sole tangible consequence was a very great loss of time for the savant and his young collaborators. It would have been much more to their advantage to have tried to secure a footing in the practical field of chemical endeavor than to have marked time in their laboratory.

UTILIZATION OF GEOMETRICAL REPRESENTATIONS

The continuity of functions is not, however, the only useful idea to be gained from the study of mathematics. It is well to have more accurate knowledge of the general forms of algebraic curves and their diversified properties. I should like to recall to your minds in a discreet fashion an error which has become celebrated in the history of the science of chemistry.

A scholar announced one day that he was prepared to demonstrate that Fresnel's theory of light was inaccurate. This theory was found to be at variance with certain observations which could not be gainsaid. In reality, just this one form of the interpolation formula, which was arbitrarily adopted, was contrary to Fresnel's theory. Numerous other formulae of interpolations, representative of actual observation as well, were all in entire agreement with the theory.

The usefulness to the chemist of having some knowledge of algebraic functions with a single variable and of the plain curves which are used to represent them may perhaps be conceded to us. But of what value is the geometry of space? However, to study the solubility of salt mixtures, there must necessarily be used surfaces in space. Simple numerical tabulations would be too confusing. The writings of Vant' Hoff are filled with such geometrical representations. They are indispensable in the interpretation of the crude results of research and investigation.

Each solid phase gives rise to a distinct surface of equilibrium. In the vicinity of the intersections of these surfaces, taken two by two, it is often very difficult to determine on which surface to place such or such an experimental result. The geometrical configurations aid materially in this respect.

But these representations are perhaps still more useful in organizing a series of experiments. The system of representation by surfaces is a very valuable aid. By means of it, there may be drawn a series of parallel curves, which are obtained experimentally, while keeping one of the factors in the phenomenon constant, either the temperature or the concentration of one of the salts. The combination of all the curves gives a comprehensive survey of the phenomenon with a minimum of experimental determinations.

Much too often do chemists content themselves with making experiments at random, with tracing haphazard curves containing the salient points on the same surface.

In the end, after a great number of determinations have been made, the problem remains as obscure as if no tests at all had been carried out. The confusion is even worse when the point in question is a function of three or four independent variables, as is frequently encountered in the problems on rapidity of reaction, etherification or saponification, for example. As, furthermore, each author arranges his experiments in a different way, no comparison is possible between the successive series of researches.

WHAT IS THE VALUE OD LOGARITHMS?

Let us leave geometry for the time being and direct our attention to algebra proper. What is the value of logarithms, differentials, and integrals? I will take, as an example, the discussion of Dumas' experiments on the determination of the atomic weight of hydrogen. This weight may be calculated from a simple proportion. Let us call P′ and P″ the weights of hydrogen and oxygen contained in a weight P of water. The atomic weight looked for is given by the proportion, $\frac{X}{16} = \frac{P'}{P''}$.

This is arithmetic. But we must know the degree of accuracy with which the number X has been determined. Let us suppose that we wish to known X accurately to about the third place to the right of the decimal point, when the weighings are made to the milligram. The problem can undoubtedly be solved by arithmetic, but only by covering pages with calculations and with the chance of making many errors therein. On the contrary, the result is obtained at once by taking the differential logarithm of the following expression:

$$dx/x = dP'/P' - dP''/P''$$

Noting that the weight of hydrogen P′ is found by subtracting the weight of oxygen P″ from that of water P, we can simplify the expression further, assuming approximately that

$$P' = P/9 \text{ and } P'' = 8P/9, \text{ to read:}$$
$$dx/x = 9dP/P - 10\ dP''/P''.$$

Each weight P and P″ is determined by the difference between two weighings. Let us grant, as will happen from time to time, that all the errors of one milligram in these weights will be in such a direction that their effects are added together. It would have then been necessary to work with 20 grams of water to obtain an accuracy of 1/1000. This explains why Dumas was always compelled to produce more than 10 grams of water, which made him start his experiments at 6 A. M. in the morning in order to finish at 3 A. M. the next night.

Lack of familiarity with such calculations exposes one to very serious errors, especially in analyses in which weights are found by difference. Here are two examples: I once had a fruitless argument with a chemist who found a percentage of water of 1.5% in a compound by the difference method. Not having taken into account the fact that this percentage was in reality indeterminate between 0 and 3%, he unhesitatingly gave an exact formula to his compound, with one molecule of water. Another chemist, director of a very reputable testing laboratory, had been entrusted with the analysis of certain foreign silica brick, which were supposed to be of good quality. Distrusting weights obtained by difference, he was compelled to weigh the silica directly and found that to be 92%, when in reality it should have been 96%. The manufacturer, guided by that analysis, made his bricks to contain 92% silica and delivered his product to the steel plant, where they melted in the furnace, in whose construction they were used. In this case the weight should have been taken by difference. An error of 10%, a quite improbable one in the weight of the alkaline earths and other bases, would have entailed an error of only 0.4% in the silica, while it is difficult to make a direct analysis of silica of more than 2% content and an error of 4% is not out of the ordinary.

CALCULATION OF PROBABILITIES

To reduce experimental errors, the same tests are often repeated many times. How then can we use the determined figures to obtain the most exact final result possible from them? Some idea of the calculation of probability is not useless. Generally, the mean is taken of these determinations, but often those, which differ most from the average value, are discarded. One chemist, who was endeavoring to correct the atomic weight of copper by means of a series of new experiments, consistently discarded the mean results of his tests, casting aside those which differed most from the atomic weight that he was trying to correct. This is the "rule of thumb" system. It would be far better not to make any experiments at all than to work in this way.

As a rule, the most likely or average result should be taken, without suppressing any figure. The probable number is obtained by arranging the results in the order of their increasing values and then picking the middle figure. In this way there is avoided the danger of giving too much weight

to an exceptionally bad result, as is the case in taking the mean, and at the same any tendency toward "rule of the thumb" reasoning, even if involuntary, is evaded.

DANGER OF TOO LITTLE KNOWLEDGE OF MATHEMATICS

To close this discussion of the errors due to an insufficient knowledge of mathematics, I will point out the danger of rushing into these calculations without an adequate training therein. A chemist wanted to solve a series of equations one day and conceived the bright idea of eliminating from them a partial and a total differential. These had been wrongly represented by the same algebraic symbol and, therefore, it no longer appeared to him that these were two entirely different quantities.

We are all familiar as well with the calculations of a foreign savant, who wished to show that the atomic weights of simple substances are all whole numbers. He believed that he deduced this fact from experimental data, when, in fact he unconsciously introduced that idea in the form of a hypothesis in his calculations. Having conceived at the beginning of his reasoning that the atomic weights are indeed whole numbers, he found the same result at the concluson, ignoring Poinsot's aphorism, "What is placed in a calculation can always be found there again."

INTRICATE DISCUSSIONS

Apart from the standard errors that a more perfect knowledge of mathematics would enable one to avoid without fail, there often exist fine points in the interpretation of experimental results the discussion of which brings out certain mathematical considerations. Here are two examples:

Raoult, in his studies on solubilities, declares that the law $(F - f)/F = c'$, where c' is the molecular concentration of the dissolved substance, is verified in the entire series of concentrations, at least for certain organic salts. I maintain, on the contrary, that beyond a concentration of 25 per cent in the dissolved body, the verification is illusory. This law cannot serve in calculations pertaining to solubilities, at least of very soluble compounds. To show where the difficulty lies, let us take an example. I will suppose that the question in view is the measurement of the slope of a path to the surface of the sun. One observer conceives the idea of taking his measurements from the center of the earth, used as the origin of the altitudes. He will then state that the variations in the level are negligible, that the path can be considered as horizontal. Another observer takes as the basis of comparison the level surface passing through the lowest point of the path. He states, using the same calculations, that the slope of the path is very steep. Rain falling on it will not make a stagnant sea, but will run away rapidly.

Let us change Raoult's expression around a bit. It becomes then a simple arithmetical operation:

$$f/F = (1 - c') = c$$

Experiments give a satisfactory proof of this formula only for values of c, included between 1.0 and 0.75, that is, of c' between 0.0 and 0.25. If the first formula appears to be more readily verified, it is because a level of comparison is taken, not as the zero value of f, but rather of F, which is very large in comparison with the smaller values of f, for which the law no longer holds good. So, the inequalities in the level of the path appear negligible, when they are compared with the radius of the earth.

We have a second problem still more difficult of solution. It concerns the measurement of a quantity which is a function of time. It is desired to know its value for an infinite time, for example, the limit of combination in a system which gradually approaches a state of equilibrium. Or again, we wish to measure a quantity, a function of the volume, as the explosive pressure of a gaseous mixture, which increases as the cooling effect of the walls becomes relatively less important. Measurements are then made in finite time and a formula is developed or a curve which enables us to exterpolate to infinity. How shall we proceed and how much confidence may we place in the results that we obtain?

Occasionally a change in the variable is essayed, taking the inverse of the variable which leads to infinity, as the independent variable. It is then sufficient to exterpolate to the zero value of the new variable. That seems very simple. The curve is traced and is prolonged through its tangent. But that mode of reasoning appears to admit that the function looked for is hyperbolic. Once that point is allowed, it is easy to exterpolate to infinity. The change in the variable does not introduce any new mathematical short cut. It serves merely to conceal the given hypothesis. Some methods of reasoning are more suitable than others and should be used wherever necessary. The choice of functions, suited to the process of exterpolation cannot be altogether arbitrary.

This problem has practical interest. In the direct synthesis of ammonia, metallic apparata are used which are capable of withstanding high pressures, while the temperature may reach and even surpass 600°C. The steel must then be elastic and it yields little by little to high pressures. What is the maximum force it can withstand indefinitely without permanent deformation? Can we conclude from a series of tests lasting 10 hours just what will happen when the duration of time is increased a hundredfold?

SERVICES RENDERED BY MATHEMATICS

The services rendered by mathematics in the studies which have just been reviewed are no different from those afforded by mathematics in all the other experimental sciences—physics, mechanics, etc. In every case where experiments are performed, it is necessary to know how to calculate the size of the relative errors, to express by means of algebraic functions the laws deduced from these experiments and finally to represent these functions geometrically so as to obtain a clearer picture of the phenomena. But the very foundations of chemistry and of stoichiometry have been established only by experiment.

CHEMICAL MECHANICS

There is a second division of chemistry, equally as important, whose practical applications become more and more numerous each day, and which strangely enough has been completely neglected by experimenters, as it has been entirely developed by the mathematicians from Sadi Carnot, the founder of thermodynamics, to J. Willard Gibbs, the American mathematical physicist. And this, notwithstanding the fact that many of the laws of chemical mechanics could have been quite easily induced from simple observations of experiment.

To understand the development of this new science, it is necessary to refer to the history of mechanics. Actual experiment has not established the general laws. They have been developed by very interesting methods of reasoning, taking as the point of departure, the impossibility of perpetual motion. Since the beginning of the world thousands upon thousands of experimenters have attempted to produce perpetual motion and have failed. We can, therefore, regard the impossibility of its realization as one of the best established truths. Every result, carefully deduced from this fact, may be considered as absolutely positive, equally as well. We have here a method of investigation which is analogous to that which Descartes used when he formulated his famous axiom: "Je pense, donc je suis."

IMPOSSIBILITY OF PERPETUAL MOTION

How can we derive the exact laws, governing natural phenomena from so self-evident and so vague a truth? Let us take a machine, which consumes energy at one point and creates it at another, for example, a falling body which causes another to rise. According to the general principle, it is impossible that a body P, descending from a height H, can raise another similar body to a height greater than H or a heavier body to the same height. Otherwise, perpetual motion would

be realized. This is sufficient to establish the laws of the lever, of the inclined plane, of the composition of forces, etc. By an analogous method, Leibnitz discovered the laws of kinetic energy.

This method of reasoning has completely disappeared from modern rational mechanics, but mention is still made thereof in the treatise on mechanics written by Lazare Carnot. His son, Sadi, conceived the idea of using this method in his study of heat. Carnot's principle is nothing but an example of such reasoning. Applying the conception of the impossibility of perpetual motion to systems of hot air or steam engines, contrasted with each other, he shows the necessity of certain relations between the specific heats or the latent heats. His reasoning is, in addition, so general that it may be applied without any further modification to chemical phenomena as well.

The laws of chemical mechanics of an exclusively mathematical origin are not very numerous, but their absolute inviolability gives them a very peculiar interest.

I wish to review them very rapidly, recalling to you at the same time the services which they have rendered to pure and applied chemistry.

FACTORS IN EQUILIBRIA

The first law is concerned with the factors in equilibria. The only factors of an equilibrium, that is to say the only quantities whose variation can modify the state of equilibrium in a chemical system, are those whose variation entails a consumption of energy. By the mere action of being present, the catalysts cannot change the direction of the reaction, contrary to what has sometimes been conjectured. In order to demonstrate this fact, it is sufficient to consider a chemical system which is thought to be modified by a catalyst, then to introduce and remove that catalyst by simple horizontal motions, which do not consume any energy. The alternate reversal of the reaction will create sources of heat and cold which will be able to actuate indefinitely a thermal motor and consequently we can obtain perpetual motion thereby. This is impossible.

The sole rôle of the catalysts is to accelerate the speed of reactions which tend to take place of their own accord. The catalysts play the same part in chemistry as lubricating oil in mechanical apparatus. The clear understanding of that law has had an important effect in the synthesis of oleum. From the time when it was realized that the lowering of the temperature alone could improve the yield experimentation was directed toward a real goal.

TWO SYSTEMS IN EQUILIBRIUM WITH A THIRD

Second Law. Two systems in equilibrium with a third are in equilibrium with each other and vice versa. At the fusion point, water and ice have the same vapor tension. To demonstrate this fact, let us imagine for a moment that this is not so, that the tension P of the ice is greater than the tension p of the water. Let us take a weight of water and freeze it, without the consumption of energy in as much as we have an equilibrium; let us vaporize that ice. The work produced will be PV. Then let us reduce the pressure of the vapor from P to p. The new work is equal to NRT° log. P/p. Then let us condense the vapor to the liquid phase, consuming the work pv. The water is brought back to its initial state.

The total work produced is equal to $PV + NRT° \log. P/p - pv = NRT° \log. P/p > O$. This is positive in nature, which is impossible, for in that case work would have been created from nothing. Consequently P must equal p.

This equality of vapor tensions at the fusion point, after having been proven by a theoretical calculation, has been verified experimentally in a very accurate manner with benzene, which has the advantage of having quite a high vapor pressure at its fusion point.

The establishment of this law permitted Van't Hoff to institute some very interesting experiments on the vapor tension of the efflorescence of salts. The existence of fixed tensions of efflorescence had been pointed out by Debray, but his experiments were not of a very high order of accuracy. The obtainment of equilibrium is very slow. At times it even appears as if the action would never come to a stop. In the course of some research on the dehydration of gypsum I have known variations in tension to be observed even after a month of continuous heating at 100°C. Disheartened by this difficulty, I abandoned my experiments. Van't Hoff conceived the idea of moistening the crystals of gypsum with solutions of $MgCl_2$ of variable concentrations and of determining at which concentration the gypsum and the dehydrated sulphate could exist together. The vapor tension of that solution, which was easy to measure, is, according to the law under discussion, equal to that of the efflorescence of gypsum.

I later applied the same principle to the study of the dissociation of calcareous spar, moistening it with a solution of the double carbonate of calcium and sodium.

STABILITY OF EQUILIBRIA

Third Law. Law of the stability of equilibria. In any system in the state of equilibrium a modification of one of the equilibrium factors, temperature, pressure, concentration, etc., produces a chemical change in such a direction that the effect of this change tends to produce a variation which is opposed to the action of the factor which has been varied. That means that an elevation in temperature produces a reaction accompanied by an absorption of heat, which tends to compensate partly for the rise in temperature brought about at first.

This law has been very readily verified in actual experiment. I need not call to your minds numerous observations, made in the course of practical tests, which have been common knowledge for quite some time.

But before this law was established by theoretical mathematics, its existence was not even suspected. It is admitted as an axiom that the dissociation of all substances increases as the temperature rises. The contrary examples, carbon dioxide, hyperruthenic acid, acetylene, etc., are considered as inexplicable exceptions. We must forget in this case the essential characteristic of natural laws, never to show any exception.

The knowledge of this law has had very important industrial consequences. It has definitely decided against the further increase in the height of blast furnaces, which was formerly thought to be advisable so as to utilize in an efficient manner the effective heat in the gases. The decrease of their temperature at the point of exit is rendered impossible below a certain minimum, because of the fact that the dissociation of the carbon dioxide regenerates heat constantly. The level at which this reaction takes place is displaced according to the height of the furnace, so as to maintain at all times a constant temperature at the top.

A much more important application of that law is found in the industrial synthesis of ammonia. Many investigators, including Thénard, H. Sainte-Claire-Deville, attempted to produce ammonia by the direct combination of nitrogen and hydrogen, but owing to their failure to recognize the function of pressure in phenomena, where chemical equilibria exist, they did not think of conducting their experiments at high pressures, as was necessary.

THE PHASE LAW

Fourth Law. The law of the phases, establishing a relation between the degree of variation of a system and diverse conditions, a number of constituents, of phases and physical actions, could have been discovered by a direct observation of facts, as in the preceding cases. It would have been simple enough, but it was not done. Before Gibbs made his theoretical speculations no one had ever thought of it. The knowledge of this law is of inestimable value to research chemists, in giving them a most useful guiding thread in the

study of systems of more than usual complexity. Van't Hoff, Bakkuis Roozeboom and their disciples would never have succeeded in unraveling systems so complicated as the solutions of acid chlorides of iron or those of the different salts, contained in sea water, without this guide. Furthermore, the idea of invariable systems, the part which they play in the representation of systems which are in the state of equilibrium led Van't Hoff to devise his dilalometric method in experimenting with these invariable points. That allowed him to attempt experiments which could not be carried out by the ordinary methods of chemistry.

ISOEQUILIBRIUM

Fifth Law. The law of isoequilibrium, also known by the name of Clapeyron—Carnot's law or Helmholtz's law, is expressed by the differential equation:

$$L\frac{dT}{T} \times APV\frac{dP}{P} \times A'EI\frac{dE}{E} = O.$$

It gives the simultaneous variations of temperature, pressure and electromotive force that one can induce in certain systems in the state of equilibrium, without disturbing that equilibrium.

It was the knowledge of that law, formulated by Clapeyron in a particularly simple case, that of vapor tensions, which led Thompson by the general application of the same principle to the phenomenon of fusion, to foretell the lowering of the freezing point of ice by an increase in pressure.

This self-same formula was used in establishing the fact that in the detonation of explosives in closed vessels there was not any greater dissociation of carbon dioxide under a pressure of 10,000 atmospheres and a temperature of 3,000°C. than at a temperature of 1,500° C. and a pressure of one atmosphere.

The greatest value of these laws is that they are absolutely inflexible, that is, they apply to all cases, without any exception whatsoever and with infinite accuracy. Every experimental result which is contrary to any one of these laws is necessarily false or wrongly interpreted. Some chemists, nevertheless, are endeavoring to disprove them. The inaccuracy of their research can be shown without any difficulty in each and every case.

We have, in addition, a sixth law, also formulated entirely by mathematical speculation, which law is very important because of its applications. This, however, is not an absolutely rigorous law.

MASS ACTION

Sixth Law. The law of mass action in gaseous systems. The following differential equation expresses this law:

$$n\frac{dc}{c} + n'\frac{dc'}{c'} - n''\frac{dc''}{c''} \ldots + (n + n' - n''\ldots)\frac{dP}{P} = O.$$

This law is absolutely accurate for perfect gases only, that is, for those which obey implicitly Mariotte's law. Gay-Lussac's law and that of the mixture of gases. Theoretically, it should be separated completely from the preceding laws, but, in reality, the known gases differ but little from perfect gases. On the other hand, the accuracy of our experiments on the phenomena of equilibrium is generally not very great as it is. So we can consider the formula, as it is given, of sufficient accuracy for all practical purposes. Its correctness is at all times superior to that of experiment.

GENERAL FORMULA FOR EQUILIBRIUM IN A GASEOUS SYSTEM

The law of mass action combined with that of isoequilibrium gives a general formula which allows us to calculate all the conditions of equilibrium of a gaseous system, provided we have our experiment made according to certain definite conditions of temperature and pressure.

The predictions which have been based on that formula have rendered the greatest service in a great number of industrial investigations. This is what was responsible for the success of the synthesis of nitric acid by means of the electric arc. Scholars and technologists had had for a long time the idea of using Cavendish's reaction in a commercial way to cause nitrogen and oxygen to combine. The yields of nitric acid that were obtained by this process were ridiculous, only a few hundredths of the quantity of air that was subjected to the action of the electric arc. They varied the different conditions under which the experiments were made, they changed the types of electric furnaces used, the nature of the current, in the hope of increasing the yield, but all in vain. A considerable amount of money was squandered in this way and then the tests were abandoned.

In the meantime, experiments in the laboratory, made at accessible temperatures, gave datum points by means of which the theoretical yield at the temperature of the electric arc could be calculated. But this was the yield that had been obtained from the very first experiments. In searching to increase the yield, we only attempted to realize perpetual motion. On the contrary, this low yield must be accepted as one of the inflexible conditions of the problem and efforts must be made to increase the absorption of nitrous vapors. This was where Birkeland and Eyde, who were the first to make nitric acid successfully on a commercial scale, won out,

To sum up, all of the science of chemical mechanics, with the exception of the law of reversibility, that is, of the very existence of chemical equilibrium, discovered experimentally by H. Sainte-Claire-Deville, has been developed by mathematical speculations. This is indeed a fact sufficiently surprising to be worthy of mention.

NECESSITY OF UNDERSTANDING MATHEMATICAL REASONING

But, some will say, if mathematics was required to create a division of chemistry, it is likely unnecessary for the chemist who uses these laws in rather simple applications to oblige himself to understand the processes of reasoning by which they were developed. All that is necessary is for him to make use of them in the most scientific way possible.

This theory may appear plausible at first sight, but in practice it proves to be entirely erroneous. You cannot use formulae in an efficient manner, whose very derivation you do not understand.

How many times have I heard scientists of standing, to whose attention I have brought such or such a law of absolute certainty, say: "Actual experience must be the deciding factor in the final analysis. If experience is contrary to the theory, then the theory must be changed to conform. In order to know a thing you must see it in the concrete." This is the reasoning of a child, who asks for the moon, when seeing an image of it in a bucket of water. If we tell him that the moon is not in the bottom of the bucket, he has also the right to say to you: "In order to know a thing, you must actually see it."

I will cite two points on which I have contended for a long time. A number of scientists have sought and still are seeking to reverse the direction of certain reactions by the use of new catalysts, ferments and other similar processes. For example, to make urea from ammonium carbonate, or saccharose from invert sugar in a reaction where the temperature is kept constant—that is trying to catch the moon in a bucket of water. All experience has been to the contrary and will always be so. A chemist who is capable of following out the reasoning of thermodynamics would never think of throwing himself into such foolhardy work. Not only would a knowledge of mathematics have prevented these chemists from wasting their time, but it would have in addition furnished them with a very useful guide in arriving at a solution of the problem, which interested them, namely, the reproduction of urea or saccharose. Here are the teachings of chemical mechanics applied to that subject.

First. The formation of these two substances being the reverse of a spontaneous reaction can be realized only at the expense of a consumption of external energy. Very likely that energy is furnished by the liver in the case of urea; in

the collar of the beet where the root and stem meet, for the saccharose, by oxidation phenomena.

Second. To bring out a reverse reaction through a spontaneous reaction, there must be a connection between the two, in the same way that a descending stone raises another by means of a cord attached to both and passing around a pulley. In chemistry we have examples of such reactions: the formation of hypochlorous anhydride brought about by the combination of chlorine with mercury. The two elements, oxygen and mercury, which have just combined with chlorine were united at first in the same compound, oxide of mercury. The transformation of carbonate of ammonia or invert sugar must undoubtedly take place through a succession of two reactions: combination of these substances with a third, then the breaking down of the complex molecule formed in this manner, with liberation of saccharose or urea.

THE MATHEMATICIANS REBUKED

I have criticised the chemists for not having shown the proper interest in mathematics, but I have a criticism as well to make of the mathematicians. They have at times made their calculations in so confusing a manner that it has been very difficult to tell which of their conclusions were of any merit. Even at the risk of being called an iconoclast, I must say that the Clausius method which has been the inspiration of many mathematicians is absolutely abominable. This scientist constantly intersperses the most fantastic atomic hypotheses with the most exact reasoning. For this reason he has arrived at some most absurd conclusions on the subject of the heat of reaction of bodies. He gives as a measure of the internal energy of gases, the kinetic energy of their molecular movements. That leads to heats of reaction which are often ten times too low. The incessant admixture of the most arbitrary hypotheses with the incontestable principle of the impossibility of perpetual motion has served to discredit thermodynamical theorizations among experimenters.

I will make a second criticism of the classical methods of thermodynamics and of all the alegbraic methods. They hide from the eyes of the students the reason for each step in the problem. A geometrical reasoning shows the why and wherefore of each conclusion. An algebraic reasoning gives a positive conclusion, in a shorter manner perhaps, but it dissimulates the successive steps in the reasoning.

These two modes of reasoning should follow each other. We commence by studying Euclidean geometry before taking up analytical geometry. We should do the same with a short course in theoretical mechanics before going into analytical mechanics. So, the famous problem of the cat led into error the most illustrious mathematicians. They did not know how to apply the nine fundamental equations of mechanics to a deformable solid. A mere bachelor of arts, who possessed a proper understanding of the fundamentals of mechanics, gave the solution to the problem at once by the simple application of the law of areas.

NECESSITY OF ELEMENTARY THERMODYNAMICS

In the same way in chemical mechanics, the classic reasonings of thermodynamics are to be sure correct, but they are often too long to follow out clearly the linking of ideas and to have them impress themselves indelibly on the mind. We must start by first studying elementary thermodynamics, where the principal theorems are directly deduced from the principle of perpetual motion. All that is required is to repeat the ratiocinations of Carnot. Perhaps, after that has been done, chemists will become less dense to quasi-obvious reasoning.

It is regrettable to think that these fundamental laws of chemistry, which have a continual use in a large number of industrial applications, should be taught only so very sedulously in France and to have to state that even today we must struggle to have accepted ideas, which, for the past 25 years, should have been familiar to all the students of the universities and the great technical schools.

CONCLUSIONS

To sum up, if we are to develop scientific methods of working in the factories, a condition which is indispensable to the economic welfare of the country, we must see to it that the chemists possess a satisfactory general training.

HIGHER SCHOOLS OF CHEMISTRY

There must be created for that purpose an advanced school of experimental physical sciences, where only those are admitted who possess a complete scientific education, such as is acquired in our large schools or who should at least be graduates in physical sciences, including a certificate in general mathematics.

In that school, laboratory work should be most important, with the recitation courses of minor importance only. In any case there should not be any more than one of these courses each day.

In this way we would be sure to recruit good chief chemists for the commercial field who would have an adequate scientific training as well as a thorough understanding of the methods of experiment. But that reform would be of little value if it was not preceded by another of even greater importance, that of the more efficient scientific training of our engineers and superintendents of plants. It is on them that the real use of the laboratory depends. If they do not know how to take advantage of the laboratory it is futile to have good chief chemists, whose work will not be put to the proper use, in the plant.

What the engineers and the operating men lack is the scientific viewpoint, that is, the belief in science and the knowledge of the proper methods for putting scientific principles and conclusions to practical use. Very few among them are really aware of the way in which the laboratory can serve them.

The method of our present secondary instruction, founded on a program of examinations, aims only to fill the mind of the student with isolated knowledge, without any inter-connection in as extensive a manner as possible: the properties of substances, the natural laws, descriptions of apparata, that is, the tangible data of science, but without any well-determined method of representation.

This is especially bad in the technical schools, where the technological descriptions, that is, the empirical recipes of the industrial "kitchens," encumber the greater part of the curriculum. We must definitely decide to reorganize the instruction of industrial science, to acquaint the student with the fact that the principal operations in the industries are dependent on certain factors which are for the most part understood at the present time and which are most often easy to measure.

It should be the particular duty of the universities to insist on the introduction of somewhat more scientific methods of research in the study of industrial problems. Through an incomprehensibly false viewpoint, their technical colleges have even surpassed the technical schools in the empirical method of instructing their students.

So we must almost revolutionize our methods of secondary as well as post-graduate education. Otherwise, we must resign ourselves to remaining for the rest of our days far behind our contemporaries.

A NEW MICROSCOPE ILLUMINATOR

Professor Alexander Silverman has invented a new illuminator for the microscope, whose special advantage is that it gives a very strong light upon the object examined, so that opaque and translucent bodies can be as readily studied as transparent ones. The top of the object on the slide can be seen with all the variations of its surface. It is particularly valuable in testing samples of metals, since it shows the presence of blow holes and pits and much detail not hitherto visible. It is likewise useful to textile experts since it shows the threads of a fabric from every angle and is also much appreciated by bacteriologists.

Repelling Poisonous Gases

A Fanning System That Was Used to Clear the Trenches After a Gas Attack

AN Englishwoman named Mrs. H. Ayrton devised a brilliant solution of the problem of dealing with poisonous gases during the war. While Mrs. Ayrton made a report upon this matter before the Royal Society of London, at a session held August 29, 1917, its publication in the Proceedings of the Society was deferred for obvious reasons, and first made its appearance October 9, 1919.

On May 6, 1915, shortly after the first German gas attack filled the world with horror, Mrs. Ayrton made known the results of her painstaking experiments with respect to the variations of pressure and the currents resulting therefrom which are occasioned in water in a state of vibration by an obstacle situated at the bottom of the containing vessels. These experiments suggested to her that it might be possible, by causing an analogous obstacle to vibrate in a suitable manner in the air in the vicinity of a trench, to excite currents similar to those produced in the water under similar circumstances. In this manner she hoped it might be possible to direct the asphyxiating gases towards the enemy and at the same time supply the men in the trench with fresh air from the rear.

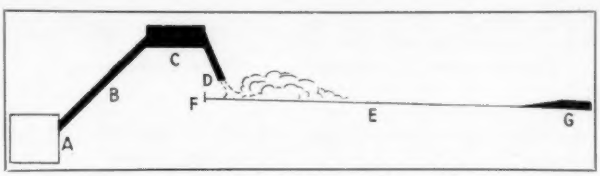


FIG. 1. EXPERIMENTAL SMOKE PRODUCING APPARATUS

Mrs. Ayrton studied the matter by means of currents in heavy smoke. She describes her smoke apparatus as follows:

SMOKE APPARATUS

"Smoke of the right kind was not easy to produce, the difficulty being that it had to be heavier than air, as the noxious gases were said to be. At last, however, after many trials, I found that smoldering brown paper gave very satisfactory results, if treated in the right way. It was burnt in a biscuit tin, *A* (Fig. 1), from which the smoke rose through a tube, *B*, to a box, *C*, issuing through a second tube, *D*. When this whole arrangement, except the can *A*, was kept wrapped in wet cloths, the smoke, cooled by the evaporation of the water and by passing through the box *C*, became heavier than air, and fell almost like water from the mouth of the tube *D* upon one end of the table *E* (6 feet by 3 feet), which had a barrier, *F*, at the end, to protect the smoke from accidental draughts. On reaching the table the smoke expanded both in height and in width, and rolled in a very realistic manner towards the further end of the table, where a miniature parapet, *G*, had been made, forming a dense cloud, 2 feet to 3 feet wide and some 3 inches to 4 inches high. (See Fig. 2, *a*.)

MODEL FAN

"My first fan was a small card on a horizontal axle, which I could alternately twirl and stop, to give the impulses to the air. This gave surprisingly good results, but not good enough. Then, remembering some startling air currents I had once observed after dropping one end of a glass tank upon a table, I thought I would try striking the parapet to give the impulses. I therefore attached a handle, at a convenient angle, to a slip of wood 4 inches by 3 inches, and with this beat with quick strokes upon the parapet *G* (Fig. 1). The effect upon the cloud of smoke advancing from the other end of the table was miraculous. After a few seconds it first stopped, and then fled backwards as if pursued, increasing in height as it went, as if it were being brushed back (*b*, Fig. 2). It never stopped till it was well behind the smoke-box (*A*, Fig. 1), about 8 feet from the fan. Even the stream of smoke that continued to pour from the outlet was affected, being converted into a vibrating stream which rose and poured back over the smoke apparatus instead of falling and advancing as before (*c*, Fig. 2). The smoke continued its backward course for some little time after the beating was stopped, and finally the whole table and smoke apparatus became completely cleared—an area of about 8 feet by 3 feet.

"The next thing was to see if a still smaller fan would clear this same area. Fans of various sizes and shapes were tried, and modifications which were found beneficial were introduced, such, for instance, as a "back" to prevent any of the air being expelled backwards towards the operator, and two hinges—one between back and blade, and the other in the blade itself—each of which allowed the parts it connected to move through a certain angle only. The final result was a fan (Fig. 3), with a blade 1½ inches square only, including the back. By tapping with this minute object on the parapet (*G*, Fig. 1), for about 6 seconds, at the rate of four taps a second, I cleared the table and smoke apparatus of an advancing cloud of smoke about 3 inches high; and even a width of 1½ feet extra on each side of a 3-foot wide table, made by extending the tablecloth, was cleared at the same time. As the height of the smoke apparatus was about 1½ feet, the air disturbance created by this fan with a blade of 1½ inches square was at least 8 feet long, 6 feet wide and 1½ feet high."

THE ARMY FAN

Mrs. Ayrton's next experiment was to determine whether a fan no larger than a man could readily wield would give sufficiently useful results to be worth putting in service at the front. The type shown in Fig 4 was the one found most successful, after tests of many models of different shapes and sizes and various materials. This was in daily use at the front after May, 1916, principally for clearing trenches, dugouts, shell holes, mine craters, etc., of the foul gases that always accumulate in them during shell fire. Formerly such places had to be avoided for hours and even for days before they could be entered, but the use of this army fan enabled them to be cleared out in a few seconds or minutes.

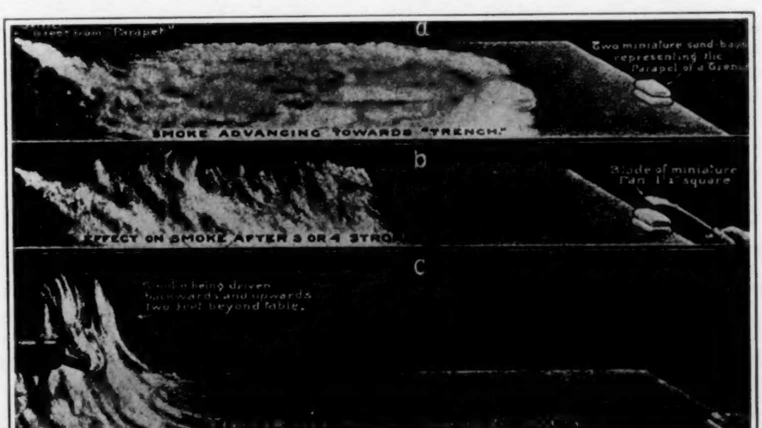


FIG. 2. THE TABLE EXPERIMENT IN THREE STAGES—*a*, SMOKE UNCHECKED; *b*, SMOKE AFTER THREE OR FOUR STROKES; *c*, SMOKE AFTER TWELVE OR FIFTEEN STROKES

The fans are made of waterproof canvas stiffened with cane, and have a wooden handle. The blade has a semi-rigid center, *A*, *B*, *C*, *D*, with loose end and side flaps and the back has an extra hingle *E* to enable it to accommodate itself to the varying shape of the backs of parapets, etc. The fans are 3 feet 6 inches long, with a blade 15 inches square; since they weigh less than 1 lb. each they can readily be folded and carried in the braces behind the pack. These handworked fans were not found powerful enough to repel gas wave attacks in the comparatively high winds employed during the latter part of the war, but their inventor thinks that these fans would have been sufficient to cope with the winds of from 2 to 4 miles per hour, in which the earlier attacks were made. However, in June, 1917, she devised a mechanically driven fan which is considered capable of driving back large quantities of gas in any wind.

In order to study the air problems involved Mrs. Ayrton made four sets of indicators consisting of numerous pieces of tissue paper about 1 inch square, dependent from horizontal stocks by silk fibres. Three of these sticks were tied to the electric lamps about 4½ feet from the ceiling, while the fourth was placed on a movable stand about 8 inches high, so that the indicators hung within an inch or two of the floor.

Experiments with these led to the deduction of the following principles: (1) the air disturbance created by a stroke of the fan travels rather slowly, a single stroke of the fan in still air taking 15 seconds to reach the indicators near the ground, 18 feet away.

(2) The maximum distance at which the disturbance produced by a single stroke is perceptible increases with the velocity and amplitude of the stroke.

(3) Each successive stroke, if the rate be above a certain minimum, carries the disturbance further, longitudinally, laterally, and vertically, till a certain maximum distance in each direction is reached.

(4) Below the minimum rate, which bears some sort of inverse ratio to the size of the fan, this cumulative effect is not produced; each stroke simply carries the disturbance to the maximum distance for a single stroke.

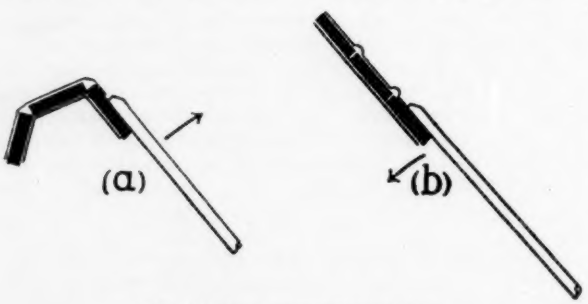


FIG. 3. THE EXPERIMENT FAN

(5) The cumulative effect of the strokes increases with the rate of striking, and also with the amplitude of the stroke.

(6) The maximum distance at which the effect is perceptible in each direction increases with the size of the fan, with the rate of striking, and with the velocity and amplitude of the strokes.

Mrs. Ayrton sums up the result of her researches in the following words: "Roughly speaking, one of these fans, in action, divides the space around it into two regions, separated by a vertical plane passing through some line in the blade of the fan parallel to its tip. *From* the region behind the fan air is sucked in *irrotational motion*, in all directions, *toward* the fan; *into* the region in front air is driven forth in rotational motion *away* from the fan. The fan cannot therefore be said to create a current in the ordinary sense of the word. What it does is to collect air from one wide region into a narrow space, and there to give it energy, both rotational and irrotational, by means of which it passes into another region, in which it moves through a longer, wider, and higher space than that from which it was collected. The fan is therefore a factory for turning still or comparatively slowly moving air into powerful vortices, which, by coalescing and reinforcing one another are able to move through an enormous area, and to drive before them, in an ascending forward-moving stream, the air or gas that previously occupied the space through which they travel."

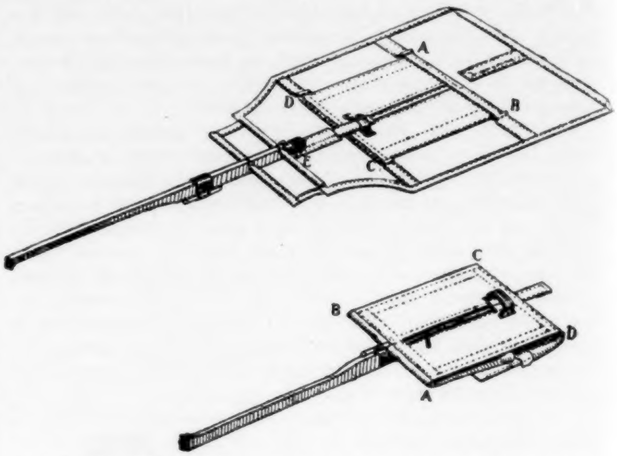


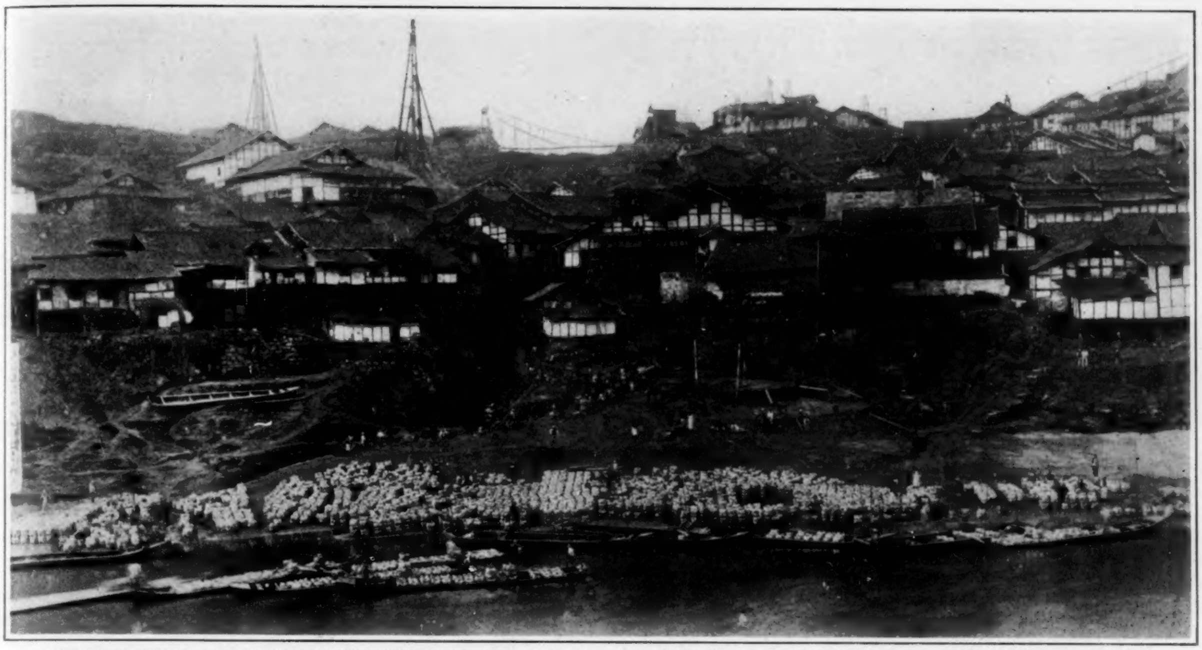
FIG. 4. THE ARMY FAN IN EXTENDED AND FOLDED POSITIONS

In spite of the fact that the immediate purpose for which these fans were created—for military uses in the war—no longer exists, it is obvious that they will find extensive employment in mines and other places where dangerous gases may collect. Perhaps, too, the principle can be so applied as to protect firemen from the effects of smoke and gas.

FOOD AND FIBRE FROM THE COMMON CAT-TAIL

THE ordinary cat-tail, which grows in marshy places and along streams over wide areas, has hitherto been chiefly admired for the handsome brown spikes from which it gets its name. Its leaves are used too for making rush-bottomed chairs. New uses have been found for it in Germany, born from their needs, and it is now announced that it is a most important source of textile fibers and also of food. This plant, the *Typha latifolia*, gives fibers which are not so fine as those of cotton or the nettle. Neither have they the softness and whiteness of fibers from these two staple plants. For this reason these fibers were employed only as a substitute for jute until about a year ago, as we learn from *Kosmos* (Stuttgart) (third quarter of 1919), but it is now announced by the Dresden Institute for Textile Research that such gratifying progress has been made in improving the process of manufacture that it will probably become of great commercial importance, and is even expected largely to take the place of wool. The yield of fiber from this plant is very high, amounting to about 33 per cent, whereas air-dried nettle stalks yield only from 6 to 8 per cent. The Institute states that such an excellent quality of finished fiber has now been obtained that it can successfully compete with wool in the markets, even if the price of the latter should go down to such a comparatively low figure as 2 marks per kilogram.

It is found also that the root of the *Typha* contains considerable quantities of nutritious material. These roots become felted together in cushions 30 to 40 centimeters in thickness, and the roots of the single plants are sometimes as much as 20 meters long and 10 centimeters thick. They contain carbo-hydrates in the form of starch and sugar, stored up for the use of the plant in amounts of as much as 25 to 30 per cent. They are thus capable of being used to feed cattle and even human beings.



GENERAL VIEW OF TSZ-LIU-CHING SHOWING BAGS OF SALT ON THE RIVER BANKS READY TO BE LOADED ON BOATS

The Salt Industry of China

Raising the Brine from Deep Wells and Evaporating It to Commercial Salt

By Herbert T. Wade

THERE are today in China certain phases of industrial activity which have endured from a remote antiquity, where fundamental engineering principles have been applied and important mechanical devices have been used without the improvements deemed essential by the Western world. Striking instances of this may be found in the salt industry, one phase of which, the manufacture of "boiled" salt from brine as carried on in the province of Sze-Chwan is here illustrated and described. In addition this industry is further entitled to interest on account of its commercial importance as a source of taxation and the industrial organization for its prosecution that has been effected in the course of centuries. With brine (which when at greatest concentration is a 26½ per cent solution of salt or sodium chloride in water) derived from wells in some cases deep enough to rival those of American oil fields, evaporated in open pans heated by coal or natural gas, and in the form of cake or crystallized salt packed for transport by boat or coolie this industry has flourished here for centuries, being described in provincial histories as early as 1,000 years ago. The first working of these salt wells is credited to the Wang and Mei families in the 3rd century B. C. and these families are now worshipped in a temple devoted to their memory.

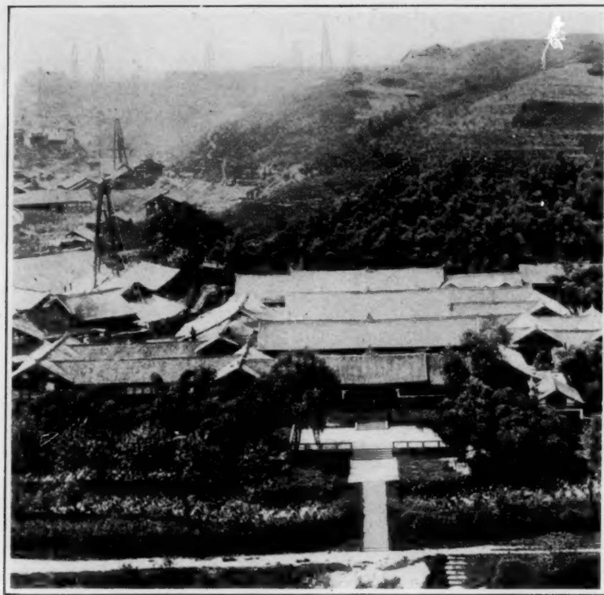
In the equipment used in this district for drilling the deep wells there are to be found certain essential elements of construction and operation that figure in a modern well sinking outfit as developed and used in the United States for hardly more than a century.

Inasmuch as salt is and has been since the earliest times of recorded history, a necessity for the human race as it is for many animals, and inasmuch as it is generally distributed, it is not at all strange that it should be one of the oldest and most flourishing industries of China and afford employment for about a million of its inhabitants. Furthermore no salt may be exported and even in the interior traffic is subjected to certain laws and regulations.

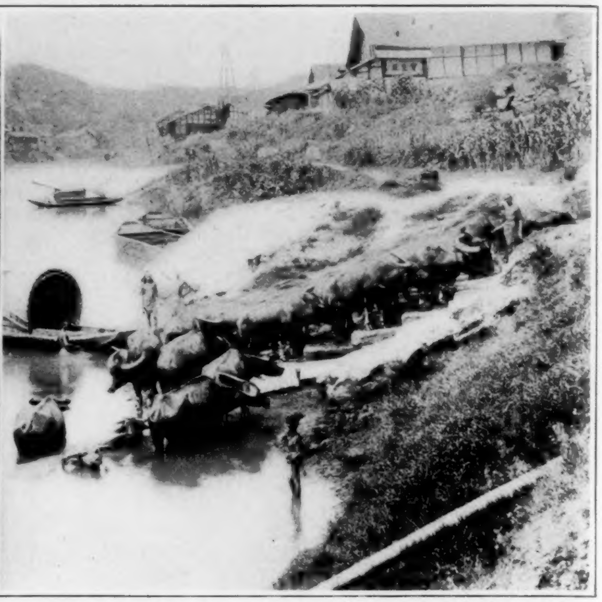
In the province of Sze-Chwan, one of the richest and most populous provinces of China, along with a vast and but little worked mineral wealth, there are occurrences of brine from which an amount of salt is manufactured in excess of the needs of local consumption sufficient to make the total output over one-fourth of the gross consumption of the entire country. In 1915 the production of the province was stated at 735,000,000 lbs. and the total consumption, 3,366,000,000 lbs.

This province of Sze-Chwan is situated in the mountains near the western boundary of the republic and its salt producing area is estimated to cover about 32,000 square miles situated along the river bottoms and the many streams. Of the rivers the Yangtze-Kiang with its tributaries is the most important as it is the best known. And on one of these tributaries at Tsz-Liu-Ching are the salt wells here illustrated.

In the salt producing area of Sze-Chwan brine wells of three types are encountered, for we are dealing here only with brine as a source of salt not the the rock salt that can be mined directly. These are (1) salt springs located either on the surface or at the bottom of shallow pits; (2) wells sunk through clay and soft rock to a depth of 1,000 feet or so; and (3) deep wells which have been drilled through hard limestone to a depth of 3,000 to 4,000 feet. Obviously the last named class must possess the greatest technical and commercial importance, for well sinking to such a depth under any circumstances is a serious and expensive undertaking carried on only when the anticipated return is sufficient to repay the initial outlay. Even judged on the basis of Chinese ideas of time and of the value of labor and material, drilling a deep brine well and its subsequent equipment and operation is a matter of long duration and one involving considerable capital. It is a business that is operated practically as a monopoly under government control as the salt tax is an important item. In 1916 the revenue from the salt tax amounted to $72,440,000 (about £7,800,000) where the total ordinary revenue was $388,009,660.



BRINE WELLS AND DERRICKS AT TSZ-LIU-CHING. A RICH WELL OWNER'S RESIDENCE IN THE FOREGROUND



A HERD OF WATER BUFFALOES WHICH ARE USED TO TURN THE WINDING DRUMS THAT RAISE THE BRINE

All of the deep brine wells are located at Tsz-Liu-Ching which is a sub-district and it is here that the accompanying photographs showing the general appearance of the field and brine wells were taken. Tsz-Liu-Ching is 110 miles west of Chung-King, an important treaty port, 1,400 miles up the Yangtze-Kiang, opened in 1891 and on the highway from that city to Kia-Ting-Fu. It is also 100 miles southeast of the capital of the province, Cheng-Tu. At times of high water in the river brine issues forth from a spring high up above the bank, and from this circumstance the district takes its name, Tsz-Liu-Ching, meaning self-flowing well.

The district so far as the brine wells are concerned can be divided into three distinct sections based on the local geology, and known respectively as the deep well section, medium well section, and the shallow well section. In the deep well section the bore holes are sunk through sandstone to a depth of from 2,500 to 4,000 feet and not infrequently natural gas is encountered in the operation. This of course is no disadvantage for while the primary purpose of the well is changed it becomes equally or even more valuable as the gas is piped off and used in evaporating the brine. Usually a gas-collecting chamber of cement is built at the top of the well under the ground. In a gas well it may be necessary to pump out the brine and prevent its access to the bore hole by the use of cement. A productive gas well of course becomes a center of salt manufacture as the brine must be conveyed here for evaporation not only from the neighborhood wells but those less favorably situated.

The deep well section is said to furnish about three-fourths of the salt produced by the district and it speaks well for the perseverance and business acumen of the Chinese that they will invest heavily in the deeper projects rather than confine themselves to those where working is easier and returns are forthcoming quicker. The medium well section includes wells from 1,000 to 2,000 feet, while the shallow well section takes in those from 200 to 1,000 feet in depth. At the latter as there is no natural gas coal is used to evaporate the brine.

In all of these districts the same general technique of process is followed, except for the evaporation, and it is distinctly uniform as with a continuous experience of more than 1,000 years the Chinese naturally have had an opportunity to standardize their methods. Furthermore they have in a large measure resisted foreign innovations, both through a spirit of conservatism and as a result of unfortunate experiences with occasional engines and other machines the use of which had been attempted. Nevertheless once European methods are introduced into this rich province with its coal, natural gas and other minerals a new industrial page far-reaching in its effects will be turned for China.

The site for the brine well is duly selected by an official and there is always an amount of new drilling in progress. Just the method that the locating official follows is not altogether apparent, but Western observers record an unusually small proportion of unsuccessful wells. With the location accomplished next comes the well drilling and the illustrations show the derricks and their general arrangement. The machinery is simple and the drilling outfit involves a house, a derrick, and a winding drum, in the construction of which, along with the necessary appurtenances, the Chinese carpenter is able to display his skill in a land where large lumber is not the rule and metal work is limited. The derrick frame is made of pine trees, several timbers usually being spliced together to secure the requisite height. Then to get uprights of sufficient strength three trees are bound together with one-inch bamboo rope and wedges are driven in under the bonds, thus making each leg of the derrick consist of a triangular log each side of which would measure about 20 inches. On the top cross beam of the derrick is placed the crown pulley of oak about 2½ feet in diameter. Over this runs the rope that carries the drill, sand pump, bailer, and other equipment in the bore hole, the rope then passing to a second pulley of considerable size on a weighted frame, under which it passes to a winding drum which revolves on a vertical axle. This drum is an interesting construction of wood and bamboo with mortised joints and splices of split bamboo rope. Usually it has 16 sides and a circumference sufficient to wind up from 54 to 65 feet of rope at each revolution. The drum itself is about 7 feet in height and is mounted 5 feet from the ground so that the men or animals engaged in turning it can pass readily beneath the rope. An important feature of the drum is the brake situated at the top to regulate the speed of revolution, especially when the drill or bailer is being lowered down the bore hole, as with the latter it may revolve as rapidly as 50 turns in 80 seconds for a 2,500-foot well, and a sudden blow at the bottom of the bore would be disastrous.

In sinking a well the first step is to excavate a hole several feet in diameter to a depth of over 200 feet. In this hole is placed in successive lengths wooden pipe of 6-inch bore made

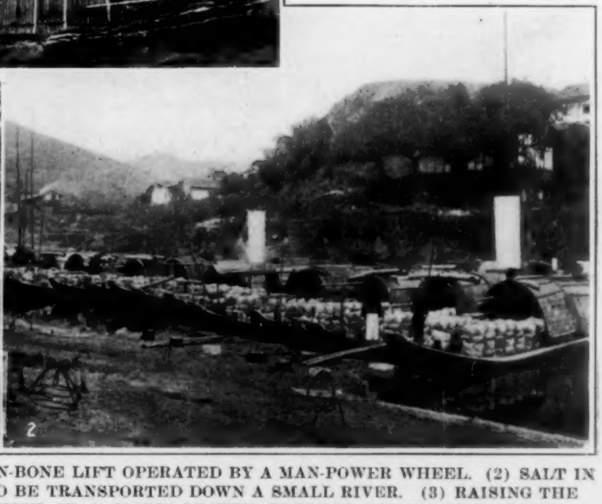
by uniting by rope binding two halves of a log that have been hollowed at the center to give the proper section. This pipe is duly jointed and is held in a central position by stone cribbing. At the upper end is placed a heavy stone cap about 30 inches square and 20 inches thick, pierced by a 6-inch hole through which the drill bit, rigging, and rope and also the bailer when attached pass. The drill used is hand forged from native wrought iron and is used as a spud drill, that is it is raised and lowered rapidly by means of a lever from the short arm of which it is suspended. Increased weight and consequent force on impact is secured by fitting an iron rod in the bamboo casing above the drill. The drill rigging is attached to one end of a split bamboo rope secured as stated to the short arm of a lever, whose long arm can be depressed by the weight of coolies stepping upon it from an adjoining platform. As they remove themselves the drill which has been raised about a foot falls and by successive steps and turns it is possible to secure as many as 30 strokes a minute of the drill, though from 15 to 20 is nearer the average rate. Each time the drill is raised the rope is given a turn. The men stepping alternately on and off, work steadily for about ten minutes and then rest while the drill rope is being lengthened. An average daily progress is about 3 feet in 24 hours. An average deep well, say, one of 2,500 feet, could be sunk under favorable conditions in from 3 to 5 years, but as a matter of fact owing to various circumstances, most of them extraneous, from 6 to 20 years are consumed in the undertaking, which ordinarily is interrupted by litigation, lack of capital, loss of drilling tools in the bore hole, and other troubles that well sinkers the world over experience. It has been estimated that on the average ten years is required for a brine well to become productive.

In the course of the drilling the sand and dirt are removed by the sand pump, a common bamboo tube 20 feet in length lowered between drilling operations. In case of the breakage of the rope and the loss of the tools the Chinese have developed special implements and devices to fish them out, quite as special and ingenious as those of a similar nature seen in the Appalachian field or elsewhere in the United States. In case they cannot be fished successfully a new drill is put down and the lost articles churned up, the same process being followed when the bailer used in bringing up the brine when the well is in production, is lost.

In the course of the drilling gas as well as brine may be encountered, but, as suggested, this is hardly a misfortune as it is utilized in evaporating the brine. Petroleum also may be met with, but as yet this is not utilized in this special field as the crude oil burns with a smoky flame and there have been no attempts to refine it. American engineers who have observed these brine and gas wells are sanguine that deeper drilling would probably bring forth petroleum in notable amounts. Considering estimates made in 1915 before the war had destroyed all ideas of value and of fixity of currency, it may be stated that an average cost then of a 1,000-foot well was \$2,100 U. S. money and of a 3,000-foot well was \$17,500 U. S. money.

Once the well is drilled and ready for operation the brine is brought up in bailers or bamboo tubes about four inches in diameter wound at intervals with stout twine, and from 60 to 110 feet in length, several pieces of bamboo often being fitted together to secure the requisite length. A filled tube contains about 650 pounds of brine. The bailer, which is attached to a bamboo rope made with three strands, is raised by power, human, water buffalo, donkey or steam, acting on the winding drum. Man power requiring as it did some 60 men and boys in a shift is passing for this service, and water buffaloes, such as are shown in the illustration, are quite generally employed. The usual arrangement is to hitch from five to seven water buffaloes to the winding windlass and then drive them at a fairly good rate of speed, as a complete pull of the rope requires from 10 to 20 minutes, the time naturally depending upon the depth of the well. Each set of animals works for two winding operations and then is allowed to rest and wallow in the river as here shown. Steam power has been tried but has not secured general adoption, while oil and gas engines also have barely gained a foothold.

When the bailer reaches the surface and is raised clear of the hole, a man displaces it over a tub and with an iron hook opens a valve in the base of the tube so that the brine which may be yellow or black, the latter being richer in salt, is discharged into a container or tub. Thence it flows a longer or shorter distance to the evaporating pans which of course must be located close to the natural gas supply. Consequently there may be employed a considerable length of bamboo pipe line and pipe lines as long as seven miles are to be found in the district. Of course in



(1) UNLOADING BRINE FROM A BOAT BY MEANS OF A DRAGON-BONE LIFT OPERATED BY A MAN-POWER WHEEL. (2) SALT IN PLAITED BAMBOO BAGS OF OVER 300 POUNDS EACH READY TO BE TRANSPORTED DOWN A SMALL RIVER. (3) RAISING THE BRINE BY A SUCCESSION OF POWER TOWERS IN EACH OF WHICH IS A HORSE-DRIVEN ENDLESS CHAIN OF BUCKETS

these pipe lines where possible advantage is taken of gravity, but naturally this not always possible and the brine may have to be elevated considerable heights before reaching the place of treatment. The inclines may be surmounted by as simple a method as using coolies to carry up buckets to an elevated tank, or a so-called dragon bone lift may be used, or a windlass lift with either an endless chain of buckets or one large bucket operating intermittently. A series of towers equipped with the first and operated by horsepower is shown in the illustrations. A compensated bucket lift is sometimes seen while on some long pipe lines there is installed at the summit of an intermediate elevation a surge tank. Often when a considerable altitude must be overcome several successive lifts are required and man or animal power utilized to operate the machines. Such installations placed in towers are often seen as shown in the illustration.

These various devices are all special applications of usual Chinese practice. Thus the dragon bone lift is used extensively by farmers for irrigation and other water raising. It suggests a wooden chain pump laid on its side, and consists of a wooden jointed chain to which transverse thin wooden vanes are attached at intervals, working in a long box open at the top and at both ends. For the brine lifts this box is about 16 feet long and 10 inches wide by 6 inches deep. At either end of the box there is a notched wheel over which the chain runs, the upper wheel of course being connected with the motive power, either a hand crank or treadmill operated by coolies, or some form of windlass or mill worked by animals, a horsepower of crude form being not infrequently used and geared to the chain.

Sometimes the distance from brine wells to evaporating pans is too great to permit of a pipe line and then it may be possible to load the brine into boats and bring it by river for treatment. One of our illustrations shows a lift operated by man power transferring the brine from such a boat to the pipe system leading to the evaporating pans. These pans are made of native cast iron about 62 inches in diameter and 4 inches deep. They are placed over natural gas burners which are rented to the owners of the brine by whom the workers and all the apparatus required for the refining process are supplied. Like other parts of the equipment the burners are made of bamboo covered with Chinese cement made of broken tile hammered fine, lime and sand or mud mixed well together and hammered into place.

The evaporation proceeds continuously until the water is removed from the brine and crystallization takes place in the desired form, crystals being removed from time to time and forming at the bottom or around the sides of the pan. The process varies somewhat depending whether pan salt or the crystallized salt is being manufactured, the difference being mainly in the control of the evaporating processes. The final product must be weighed and registered by Government officials for purposes of taxation as the industry is controlled by the Government. The packed salt is then transported by river boats as shown, or it may even be carried overland by coolies. That going out of the province is consumed in the adjoining provinces of Hupeh, Kueichow, Yunnan and Kansu.

In the Tsz-Liu-Ching district the average daily output of a salt well has been estimated at three-quarters of a ton and about one-half of some 10,000 large and small brine wells are usually active, with a total annual output of about 130,000 tons. Of course there are comparatively few large and deep wells. It has been estimated that there are usually about 500 new wells in course of drilling.

Tsz-Lieu-Ching is a wealthy town outside of the provincial jurisdiction for here is located a branch office of the national Salt Gabelle or agency for administering and collecting the salt tax. There is a central salt administration in Peking under the control of the Minister of Finance with a chief inspectorate under a Chinese Chief Inspector and a foreign Associate Chief Inspector, who superintend the issue of licenses and the compilation of reports and returns of revenue. With the exception of a few provinces all the salt producing areas of China are under a tax law which imposes a regular salt duty of $2.50 per 100 catties (1 catty equals 1 1/3 pounds). This duty is collected at all salt producing areas and affords the return already indicated.

NOTE.—Those interested in the Chinese salt industry may consult with profit a series of papers by H. K. Richardson on this subject in Volumes XVI and XVII of *Metallurgical and Chemical Engineering*, New York, 1917, to which the author is indebted for much of the foregoing material.

PARACOURMARONE

IN the June number of the *Journal of Industrial and Engineering Chemistry*, page 549, facts concerning the manufacture and use of paracourmarone resin in varnishes are given in some detail. This artificial resin is now prepared on a commercial scale in the United States by the polymerization of the courmarone and indene in certain aromatic naphthas. Recent researches have shown the way to produce materials of lighter color and higher melting point than previously, which material is better adapted to certain types of varnishes.

When suitable naphthas are treated with strong sulphuric acid a polymerization of the courmarone, etc., takes place, the products remaining in solution. There are other ways of effecting the same result. The naphtha is then separated from the polymerizing agent, neutralized and distilled to separate it from any unpolymerized material. The result is a liquid residue, which on cooling solidifies and this is paracourmarone resin.

This material when properly prepared is amorphous and brittle, very much resembling rosin. The inferior grades are black, but those used for varnish range from a reddish brown through orange yellow, to a very pale yellow corresponding to the different shades of rosin beginning with *E* and running through to WW. The most satisfactory procedure for making a varnish using paracourmarone consists in adding the required amount of the artificial resin in the form of small lumps to a mixture composed of 15 parts of pure raw linseen oil and 100 parts of China wood oil, with which a cobalt linoleate may be used as a dryer. The mixture of oils and resin are then heated at the rate of about 2½°C., (equivalent to 4.5°F.) per minute up to a temperature of from 290° to 320°C. (555° to 610°F.). When the desired temperature is reached the kettle is removed from the fire and allowed to cool, and when near the boiling point of the thinner to be used this is added in an amount determined by the type of varnish and the final viscosity wanted. When the thinned mixture has cooled somewhat below 100°C. the dryer solution is stirred in. This may be prepared by dissolving 100 parts of cobalt linoleate in 84.2 parts of raw linseed oil, heating the mixture to 200°C. for two hours adding 42.1 parts of bodied China wood oil and continuing the heating with frequent stirring at 200°C. for one hour. When cooled to 160°C. the resulting solution is poured into 600 parts of coal tar naphtha paint thinner, yielding a final dryer solution containing 1.03 per cent of cobalt.

The rubbing quality of such varnishes appear to be satisfactory, producing smooth coats with a satiny luster free from imperfections. The water resisting properties with cold water show the varnish film quite able to withstand its action without dulling or whitening. The varnish is as resistant to hot water and to weathering as the best commercial varnishes using the imported gums. In hardness, toughness and elasticity the films are also similar to those from the best commercial varnishes.

This artificial resin can be produced to sell below the price of imported gums, can be made of uniform quality, melting point and color. It is free from extraneous matter, shows minimum volatilization during the heating of the varnish, and being chemically inert to a remarkable degree, is quite resistant to alcohol, fruit acids and vinegar, and the action of the alkalies in soap as well as ammonia.

Using Stenches as Mine Warnings*

Disagreeable Odors Introduced into the Compressed-Air Line as a Fire Alarm

By S. H. Katz, V. C. Allison and W. L. Egy

IN mines liable to fires from electric wiring, open lights, spontaneous combustion, or other causes a means of warning the miners in order that they may reach a place of safety and avoid being trapped by the fire is of great importance. This is particularly true in some metal-mining districts where mine fires are frequent. The shafts there are usually deep and heavily timbered, so that the fires spread rapidly and air currents of high velocity may carry the poisonous fumes from the fire to many parts of the mines in a very short time.

Electric gongs have been tried in metal mines and also in the coal mines of Illinois, but have not been satisfactory. The sound cannot be heard far, and the circuits are kept in repair with difficulty because of the excessive corrosion of the wires and because of accidental grounding. As a means of signaling, some mines in the West have placed three-way valves, essentially the same as the stop and waste cocks in water lines, at various points in the compressed-air line. Turning one of these valves closes the line from the compressor and releases the air from that branch of the pipe. Interruption of the flow of air is the signal for the men to leave the mine. This method, too, is not satisfactory, because accidental interruptions cause needless confusion and stopping of work.

At the Belgrade mine fire at Biwabik, Minn., on February 1, 1919, water was turned into the compressed-air line to warn the miners of danger. When the miners noticed the water they ran from their working places and warned the others. The lives of all the men but one, who lost his senses through fear, were saved.

Telephones have been placed in many large mines, the system running to the vicinity of all the important workings. This means hitherto has been found the most effective for warning miners.

The Butte & Superior Mining Co., of Butte, Mont., J. L. Bruce, general manager, tried the method of introducing valeric acid into the intake of the air compressor, and found that only a few minutes were required for the pungent odor of this substance to reach the farthest working parts of the mine. The method was brought to the attention of G. S. Rice, chief mining engineer of the Bureau of Mines, by Daniel Harrington, mining engineer of the bureau, and at the instigation of Mr. Rice an investigation of various stenches was undertaken.

Stenches as a warning have a decided action; they exert a positive effect because of their offensiveness. When miners smell the disagreeable stenches described in this paper, they instinctively desire to obtain pure air at once. If the miners cannot obtain pure air readily, however, they can tolerate the stenches without much discomfort.

The velocity of air through compressed-air lines in metal mines is usually hundreds or even thousands of feet a minute, so that transmission of a stench is rapid. Warning by stenches is particularly adapted to mines equipped with compressed air. In coal mines, where only the ventilating current is available for carrying a stench, the average velocity is low, of the order of 200 feet a minute or less. If the velocity of the air in a compressed-air line is rapid, a small quantity of material would give more effective warnings than the same quantity in a ventilating current, because of being liberated in concentration at the points where most needed, and being less diluted with air. However, the method may be useful in some mechanically ventilated mines where compressed-air lines are unavailable.

*Abstract of Tech. Paper 244 of the U. S. Bur. of Mines.

The stenches were first tried in the laboratory and those that seemed most promising were then tested in the experimental mine of the Bureau of Mines. Later tests were made in the large metal mine of the North Butte Mining Co., at Butte, Mont., the Central mine of the North Star Mining Co., and the Empire mine of the Empire Mining Co., both of Grass Valley, California.

Of the chemicals tried, butyl mercaptan is the best adapted for the purpose in view, but as yet there is no commercial source of this substance. Ethyl mercaptan, butyric acid, and amyl acetate, which may be obtained of chemical supply houses or manufacturers, give excellent results.

Obviously a stench should not be toxic. In order to make the warning harmless, under any possible conditions of mismanagement, nontoxicity or absence of injurious effects on the human system is the first necessity. Also, the vapor must have no lachrymatory or other irritating effect on the eyes, lest miners become unable to find their way.

The vapor pressure of a chemical may be considered a measure of the rate of evaporation. The higher its vapor pressure, the more rapidly a substance evaporates and the greater the quantity of it that a given volume of air will hold. Moderate vapor pressure is needed to prevent the possibility of an excessive concentration of the chemical in any part of the air of a mine. Although it is advantageous to be able to create in the escaping air such concentrations as when diluted with the surrounding air in the mine, will give the desired effect, yet the maximum concentrations possible should be low enough to prevent harmful effects, even if breathed undiluted for a time. By the use of chemicals with a lower vapor pressure, the breathing of vapors in excess of certain comparatively low concentrations is automatically impossible.

The odor preferably should be disagreeable, rather than pleasant, in order to be most effective as a warning, and should be distinctive, so that there would be no danger of mistaking it.

Substances that can be readily obtained in the market at moderate prices are to be given preference; but if such substances do not answer the purpose, those that may be prepared without difficulty in the chemical laboratory are to be desired.

EXAMINATION OF ODORS IN THE LABORATORY

The apparatus used for the examination of the stenches, the "odorometer," consisted of a number of flow meters of the Venturi type, so arranged as to pass a measured volume of air, flowing at a uniform rate, over or through the substance, and then to mix this concentrated air-vapor mixture with pure air in various measured quantities flowing at uniform rates. The concentration of the substance was measured by determining the loss in weight after the measured air had passed through it. From this data and the total volume of air with which the substance was mixed, the concentration in parts per million, grams per cubic foot, and cubic centimeters per 1,000 cubic feet were calculated. The air with the admixed chemical was passed through a rubber tube with a glass funnel at the open end. The funnel, when placed over the nose, enabled the operator to smell the mixture before it became contaminated with room air.

The apparatus was placed in a hood provided with strong suction and the room was well ventilated to prevent the operator from continually smelling the odor, as this would tend to lessen his sensitiveness to differences in the degree of concentration.

An arbitrary scale for odors of five degrees of intensity was

adopted. The degrees are called: (1) Detectable, (2) faint, (3) quite noticeable, (4) strong, (5) very strong.

Only one inhalation was used to determine intensity. The position on this scale of any strength of odor depends on the sensibility and judgment of the individual, but with one person conducting a test from start to finish, the method has been found decidedly satisfactory.

TESTS IN THE EXPERIMENTAL MINE

The experimental mine of the Bureau of Mines, shown in Fig. 1, consists of two parallel drift entries, 1,308 feet long, called the "main entry" and the "air course," and one pair of butt entries, driven to the left at points 850 and 900 feet from the mine opening, with a set of five rooms turned from No. 1 butt. The air enters the air course at a point 135 feet from the mouth, from a gallery slant 350 feet long. For these tests the fan was run as a blower, the air current intaking on the air course and returning on the main entry.

The compressed-air line extends in the air course to a point 650 feet from the mouth (A 650), where it passes into an expansion tank and water trap, with a small opening for the discharge of the accumulated water. The tank is placed in the cut-through, about 15 feet from the ventilating current. From this point the line extends along the air course, up No. 1 butt, and through the rooms, as shown in Fig. 1. In the first cut-through between the butt entries the air operates a small reciprocating water pump. The line is 2-inch pipe throughout.

DETAILS OF THE INJECTOR

The liquid chemical was dropped into the compressed-air line just outside the engine room containing the compressor and receiver.

The mechanism used for injecting the chemicals into the air line is shown in Fig. 2. It consisted of a pressure injector, such as is used for oiling steam-engine cylinders, which was screwed into an enlarged section of pipe built into the air line. Pressure was admitted to the space above the liquid; a needle valve on the bottom regulated the flow of liquid into the pipe. Directly underneath the injector a wire screen was placed in the pipe, slanting upward in the direction of the air flow. A second screen was placed about one-fourth of an inch behind the first screen in order to catch any drops which might be thrown through the first screen before being volatilized. The container being calibrated, the volume of liquid present at any instant could be read directly by means of a vertical scale on the outside of the glass. By taking frequent readings of the quantity remaining in the container and timing the flow with a stop watch the rate of injection of the substance into the air line could be carefully regulated.

METHOD OF CONDUCTING TESTS IN THE EXPERIMENTAL MINE

A measured amount of the liquid chemical was placed in the injector, and at a prearranged time this was allowed to drop on the screen in the air line, the rate of injection being controlled by adjusting the needle valve.

The air was allowed to discharge into the mine at the positions of the observers, as shown in Fig. 1. A compressed-air puncher was operated at the face of one or the other butt entries (observers 3a and 3b), the pump in No. 1 butt was started (observer 2), and valves at the expansion tank at A 650 (observer 1), and near the face of 5 room (observer 5), were opened just enough to allow a slight leak. In some of the tests, when the puncher could not be operated, the valve was opened to allow about the same quantity of air to pass as when the machine was in use. Each of these observers was placed about 15 feet from the outlet of the pipe, except at the puncher where the men were operating the machine in the usual manner. In addition observer 4 was placed in No. 2 butt, just out by the last cut-through, and another (No. 6) at the mouth of the return entry. In order to reach this last observer, the odor had to be carried by the ventilating current a distance of 1,950 feet—that is, from the junction of No. 2 butt, and the last cut-through, near observer 4. The time at which the odor reached each station was noted, the watches of all observers having been previously compared. The observers were instructed to record in each test the time at which the odor became so strong that it would be observed with certainty, even if it were not being expected.

TESTS IN THE NORTH BUTTE MINE

Tests were conducted at the Granite Mountain shaft of the North Butte mine, Butte, Mont., to determine the effectiveness of stenches under actual working conditions in a large metal mine. The following extracts are from a report by Daniel Harrington, mining engineer of the bureau, who directed the tests:

"The North Butte mine, chosen in which to make the test, is one of the largest and most extensive mines in the Butte district, having active workings at practically all horizons from the surface to the 3,600-foot level and an output of over 2,000 tons per day. Several different veins are worked, and the mine has upward of 30 miles of levels and many additional miles of raises, manways, stopes, etc. Over 1,000 men, about

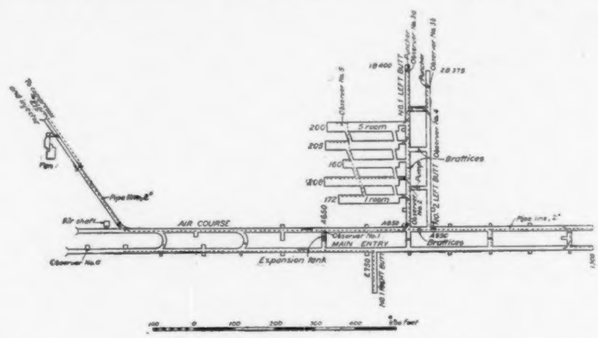


FIG. 1. PLAN OF EXPERIMENTAL MINE, SHOWING CONDITIONS DURING TESTS OF STENCHES

500 being miners, are employed underground on two shifts, when the mine is producing at a maximum rate, though the underground force at time of making the tests was probably less than 700, probably 375 being miners.

"Approximately 10,500 cubic feet of free air is compressed by three air compressors near the Speculator shaft and conveyed by pipe about 700 feet to the collar of the Granite Mountain shaft, thence down the Granite Mountain shaft to the various levels, the air pipe on various levels being 2 and 3 inches in diameter. All working faces are supplied with compressed air, and when working at maximum capacity the three compressors are unable to supply enough air to keep the pressure in the underground lines much above 50 pounds, and the pressure frequently is less than 50 pounds. At time of making the stench tests only two compressors, with a capacity of about 7,000 cubic feet of free air per minute, were required, giving a surface air pressure of nearly 90 pounds and an underground pressure of about 80 pounds.

"From the above it will be seen that the velocity of compressed air in pipes would be much greater when the mine was working at maximum capacity (as in the summer of 1918) than when the stench tests were made; hence stench odors would probably be transmitted to working faces more quickly under conditions of maximum ore production than the tests show.

"The mine has about 350 compressed air drills at work when operating at maximum capacity, and at the time of making the tests probably 150 drills were in use. Drills will, in general, use about 50 to 80 cubic feet of air per minute, and a drill will average 1½ hours actual drilling (using compressed air) per 8-hour shift.

"The mine is one of the best ventilated in the Butte district, having two upcast shafts, each with an electrically driven

suction fan at the surface and one upcast shaft using natural ventilation. The main downcast shaft is the Granite Mountain, which distributes more than 82,000 cubic feet of air per minute to regions below the 2,000-foot level, as follows: 8,600 feet on the 2,200-foot level, 17,800 feet on the 2,400, 22,200 feet on the 2,600, 16,300 feet on the 2,800 and 17,200 feet on the 3,000-foot level. In addition, a small fan electrically driven forces air through canvas pipe from the 3,000-foot level to the faces of cross-cuts between the 3,000 and 3,600-foot levels; and on various levels air is distributed to the faces of drifts, crosscuts, raises, and stopes by means of small fans and canvas pipes. The velocity of air in the canvas pipe ranges from 2,000 to more than 5,000 linear feet per minute. This mine is much better ventilated than most metal mines, but it should be borne in mind that the stench tests as conducted were not in the slightest degree affected by the fan ventilation and the results attained would have been the same had there been absolutely no fan ventilation in the entire mine. This is important, as it would be fatal to rely on fan ventilation to convey warnings in metal mines. Comparatively few metal mines make any attempt to insure air circulation at the working faces where most of the men would be working and where the warning would be most needed. The tests show that fan ventilation is not necessary to the success of stenches as warning in metal mines, the compressed-air system being sufficient in itself.

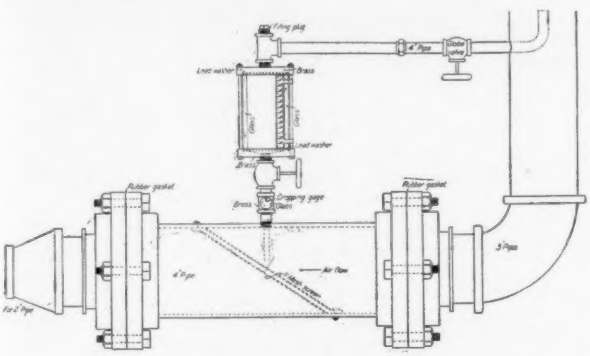


FIG. 2. DETAILS OF THE APPARATUS USED FOR INJECTING STENCHES INTO THE COMPRESSED-AIR LINE

"Through th kindness of Mr. N. B. Braly, general manager of the North Butte mine, an apparatus for introducing the stench had been placed in a building near the collar of the Granite Mountain shaft, the apparatus being so situated and constructed as to be of use permanently provided the tests were a success. Unfortunately, about 25 feet or more of 1-inch pipe intervened between the point of introducing the stench material and the point at which it reached the main air pipe. Tests 1 and 2 proved that the small amount of stench fluid, with essentially the same pressure both before and behind it would not be effective by the time it traversed this 25 feet or more of small pipe. After the second test I pointed out this to the general superintendent, Mr. L. D. Frink, and he had the introducing apparatus placed immediately over the main air pipe in such manner that every drop of the stench fluid immediately entered the main pipe. With this rearrangement of apparatus Test 3 was a complete success."

CHARACTERISTICS OF THE STENCHES USED IN MINE TESTS

Butyl mercaptan has a powerful and exceedingly disagreeable odor, even when used in small concentrations. The odor is characteristic of this substance and will not be confused with any odors commonly found in mines. The rapidity of evaporation is moderate; therefore, there is little danger of getting too strong a concentration. If the substance is used in excessive quantities, it is difficult to clear the mine of the odor. The chief disadvantage to using butyl mercaptan as a stench warning in mines is that it cannot be obtained in the market at present, but a manufacturer is experimenting with a view to producing it. Butyl mercaptan can be made in the laboratory, and, if desired, instructions for preparing it will be furnished by the Bureau of Mines.

Ethyl mercaptan is also an excellent stench, having a disagreeable and characteristic odor. Ethyl mercaptan evaporates rapidly, however, and care should be taken not to use it in greater concentrations than 8 c.c. per 1,000 cubic feet of free air. When not in use it should be kept in a tight container. Ethyl mercaptan may be obtained in the market in 1-gallon cans or 5-gallon drums.

Amyl acetate, which is artificial banana oil, evaporates readily and gives a rapid and sure warning throughout a mine. The odor is rather pleasant to most people, and therefore is not so suitable a warning as one more disagreeable. Amyl acetate is inexpensive and can be readily obtained from any paint dealer or chemical supply house in quantities desired.

Butyric acid is readily obtainable in the market. Unless the concentration used is large, however, the odor may not be distinguishable from other odors existing in mines. The odor is very unpleasant when strong, but is not nearly so disagreeable as that of the mercaptans. Butyric acid evaporates slowly, as compared with the mercaptans and the amyl acetate, and difficulty might be experienced in having the air take up enough to permeate thoroughly a very large mine, or one using a large quantity of air in the ventilating current.

Valeric acid, which may be readily obtained, has about the same properties as a warning stench as butyric acid. The odor, however, is not easily distinguished from mine odors. This substance evaporates much more slowly than butyric acid, and strong concentrations in air are difficult to obtain. Where the ratio of ventilating current to compressed air is high, it would probably be impossible to pass enough of the material through the air line to obtain the desired concentration throughout the ventilating current.

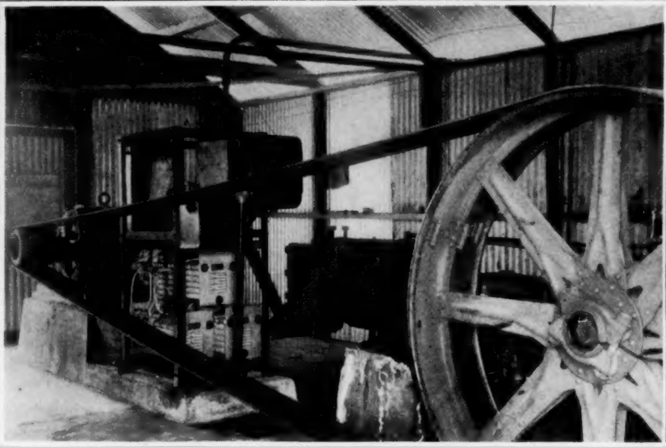
All of the above substances are known to be harmless, even in strong concentrations. When the tests were made in the experimental mine, the men were told to go to fresh air if affected by the smell, but they all stayed in their places. They knew that a small quantity was to be used and expected the odor to last only a short time. One man complained of a slight headache during the first test, in which butyl mercaptan was used, but this passed away after he had been assured that the vapor was harmless.

The tests at the experimental mine were performed in summer. Those at the North Butte mine were performed in February, when the outdoor temperature was 24°F., and that of the air in the pipes at the point of injection was 93°F. It is possible that, in cold winter weather, with cold air in the pipes at the stench injector, different results would be obtained on account of the lower vapor pressures at low temperatures. Where the pipe line is exposed to extremely cold weather, ethyl mercaptan should be used in order to obtain sufficiently rapid evaporation, because the other less volatile compounds might be condensed in passing through the cold pipe.

At cold winter temperatures, amyl acetate may give trouble by flowing more sluggishly. No trouble would be experienced, however, at the usual engine-room temperatures.

After the apparatus has been used for sending a warning, it should be taken apart and thoroughly cleaned, particular care being taken to see that none of the liquid remains in the pipe. This is to prevent the possibility of an excess quantity being used in a subsequent warning.

If it is desired to teach the miners the nature of the odor to be used as a warning this should be done by having them smell vapor issuing from a nozzle or other small outlet, and not by putting them into a room where the air is saturated with the odor. If the latter method is used, the miner's garments, unless thoroughly aired, might carry enough of the vapor to give a false warning later in the day.



A 15-30 HP. MOTOR AND CONTROL OUTFIT SHOWING REPLACED STEAM ENGINE USED AS A COUNTERSHAFT OPERATING A WELL AT COALINGA, CALIFORNIA

A WELL AT MONTE CHRISTO, CALIFORNIA, SHOWING THE DISCARDED STEAM ENGINE WHICH HAS BEEN REPLACED BY AN ELECTRIC MOTOR

Electricity in the Oil and Gas Industries

A New and Promising Field in Which the Electric Motor Is Replacing the Steam Engine

By C. S. Carter

OIL and gas have a common source. The efforts necessary to obtain the one are equally necessary to obtain the other, and often when one is being sought the other is found. Consequently the two industries—if they may be called separate industries—are very closely related, and the information given herein applies to both oil and gas wherever the same processes are necessary in order to deliver the two products to the consumer.

The methods of drilling for oil are the same as those employed in drilling for gas. After a well is brought in, of course, it is not necessary to put the well on the pump in the case of a gas well, as is generally done with oil wells, but often water has to be pumped from a gas well and this requires pumping power. The refining of oil does not have a corresponding process in the delivery of gas to the consumer, but the manufacture of gasoline from casing head gas is a rapid development in which electric power is playing a part of ever-increasing importance.

OIL AND GAS PRODUCTION

The actual drilling of wells by electric power is a comparatively new field of operation for the motor, but it has been given sufficient trial to make it very promising that electricity will sooner or later replace other methods of drive for this purpose, wherever power companies can be induced to extend their lines.

The pumping of wells by motors was accomplished a good many years ago, even when the electrical industry itself was comparatively new. The motors, of course, had not reached the present high state of development, but the subsequent study which electrical engineers have given to field conditions has enabled the oil well motor to keep pace with the general progress of the electrical industry. Suffice it to say, in no device for the furnishing of power can its characteristics be so predetermined nor can these characteristics be so carefully designed to meet an extremely varied set of conditions as in an electric motor.

DRILLING BY CABLE TOOL OR STANDARD METHOD

Two considerations have to be taken into account when drilling by the cable tool or standard method, that is—the necessary motion for the drilling operation and the necessary torque or power to handle the casing, tools, etc. The driving unit should increase in speed when the load is released on each stroke, so that the bit drops freely. The bit should also be caught on the rebound, so that the drilling cable is not whipped at each stroke. The actual power required for this operation is from 15 to 30 hp., at comparatively low speeds. To handle the casing and tools a capacity of from 50 to 75 hp. with heavy overload torque for short periods is required.

The two-speed oil well motor used for this purpose is rugged and is built for heavy torque so that it can exert several times its full load torque for short periods of time without injury. The comparatively small diameter of the rotor means small flywheel effect, thus giving a quick reciprocal motion which is necessary for fast drilling. For handling casing and bailing sand, the motor is operated at high speed in order to save time. The operation of the control is extremely simple and does not require any technical knowledge. The speed control gives almost any pick-up speed that may be desired, thus furnishing the necessary "kick" or motion at each stroke of the bit.

REQUIREMENTS FOR ROTARY DRILLING

The principal requirement for rotary drilling is the continuity of service of the "slush" pump. This requires a 15 hp. to 30 hp. motor with a large range of speed control in order to vary the pressure. This pressure may run as high as 500 lbs. per sq. in. Since it is usually very dirty and sloppy at the pump, it is preferable to belt the motor to the pump with the motor some distance away.

To operate the rotary equipment a drilling motor is belted to a countershaft and the countershaft is connected by chain to the rotary rig, in exactly the same manner as is the steam engine. The controller wheel is connected by a flexible wire to a point close to the driller's position.

MOTORS FOR PUMPING SERVICE

Oil well pumping naturally falls under two classifications, identified by their method of pumping. These two methods are really determined by the depth of the well. Within certain limitations the shallow wells are "put on a power" and deeper wells are pumped "on the beam."

In pumping "on the beam" the standard derrick is left at the well and the band wheel is connected to the motor through a countershaft.

The motor recommended for this service is a 15-30 hp. two-speed, variable speed motor, giving moderate speed for pumping on the 15 hp. winding. The pumping side of the motor gives a motor speed, which can be varied from 600 r.p.m. to 300 r.p.m., with a corresponding variation in pumping speed. The motor may be operated continuously at any speed between these limits giving a wide range of speeds to fit the characteristics of the well.

When it is desired to clean the well or remove rods, tubing, or casing, the simple moving of a switch handle changes the motor over the 30 hp. side, giving twice the power and speed for cleaning and roustabout operations.

THE CONTROL EQUIPMENT ALL WIRED UP AND READY TO BE INSTALLED

The motor used for this service is designed for operations on 440 volts, three-phase, 60 cycle, but will also operate satisfactorily on 50 cycle, circuits. It has a heavy rolled steel frame and heavy substantial bearings, giving the strongest possible mechanical construction.

Control equipment for pumping must be simple and rugged in order to give the operator at all times the exact motor speed he requires. The wide range of speed control makes the equipment suitable for all needs of the oil and gas fields.

Without going into details as to the numerous advantages obtained by the use of electric drive, it may be said that the principle advantages to the operator are increased production and decreased operating costs. Also the economy of operation secured often enables wells to be pumped profitably at a lower production than is possible with any other form of power.

The large number of electric motors now used for pumping wells in the various oil fields afford abundant evidence of the desirability of this form of drive. One of the large power companies in California supplies power for the operation of more than 1,100 wells.

Specific example of the savings effected is well illustrated in the case of a certain oil company in the California fields, which formerly had a battery of boilers supplying two steam-engine-driven wells. The operation required 25 barrels of oil a day, at a selling price of $1.23 a barrel. There were two attendants at a cost of $120 a month each, making an operating cost of $922.50 for fuel and $240 for labor, a total cost of $1,162.50 a month. Also a part of the superintendent's time was devoted to the care of the boilers and engines.

Electric motors were substituted for steam engines and the total power costs amount to about $2 a day or $60 a month. The motors require so little attention that the superintendent himself looks after them, and thus a net saving of approximately $1100 a month is effected.

Another oil company—a small producer—was operating a well by steam, the fuel alone costing him about $300 a month. This customer installed a 15-30 hp., 2-speed, oil well motor and his power bill now runs up from $15 to $18 a month.

These are only a few of the many cases where material saving has been effected.

CASING HEAD GASOLINE INDUSTRY

A rapid development closely allied to the producing end of the petroleum and gas industries is found in the extracting of gasoline from gas.

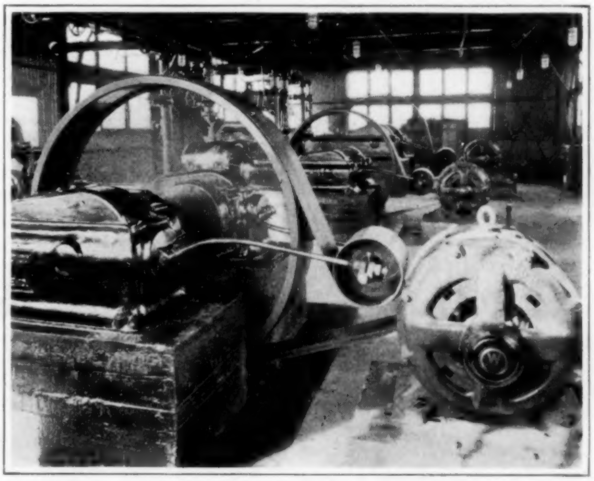
The casing head gas is taken from the wells through long vacuum lines to a central vacuum station, and several vacuum stations are connected in turn to a central compression station. The contracts between the gasoline companies and well owners usually call for the return of the residue gas to the well owners.

This expensive gas line together with the difficulty of getting this gas back, particularly in cold weather, presents some unusually difficult problems to the gasoline manufacturer. Electric drive permits a better distribution of the vacuum stations, since with a gas engine drive it is necessary to concentrate this equipment in order to minimize attendance. With electric drive no attendance is necessary at the vacuum stations. These stations, electrically driven, can be located more efficiently with respect to the wells, thus cutting down the vacuum lines which are hard to maintain. Furthermore, by supplying electric power to the fields over the same transmission line it is possible to eliminate entirely the residue return line.

Gas engine driven compressors in gasoline plants have at times been the source of some very destructive and fatal explosions due to the proximity of the highly volatile gases to the engine ignition. Squirrel cage motors practically eliminate this hazard. All switches and circuit breakers are oil immersed.

OIL REFINERY USES OF ELECTRICITY

All refineries require electricity for illumination. Power is also required for oil pumps, air compressors, machine shops, pumps for water supply, circulating pumps for condenser boxes, motors for wax plant, and electricity for arc welding.



GASOLINE PLANT NEAR BARTLESVILLE, OKLAHOMA. THREE 50-HP. MOTORS DRIVING TWO 2-STAGE VACUUM PUMPS AND ONE COMPRESSOR

In many fields where electricity is not available the question of lighting the rigs and other parts of the field equipment has been one affecting the safety of the installation and the efficiency of the labor. Gasoline compressor stations and vacuum stations require safe and effective illumination. This is possible only with electricity. Many of these stations which are not entirely electrified are equipped with direct current generators for lighting. The generator is sometimes belted to the line shaft driving the station pumps.

The Development of Welded Ships*

Some of the Advantages of Electric Welding Over Riveting in Ship Construction

By William T. Bonner

ELECTRICALLY welded jointures, when properly made, are superior to every other method of connecting together the various parts of a ship.

Ninety per cent or more of those who have thoroughly investigated the subject are convinced that welded joints *can* be made more than 100 per cent efficient for strength, but most of them qualify that conviction with the corollary that 100 per cent strength welds can only be obtained by competent, conscientious operators.

As compared with riveting, welding affords the true mechanic far greater opportunity for the exercise of skill in the heat treatment of metals, study of relations between electric energy and the physical structure of his work, ingenuity in the arrangement of his jigs and forms and, according to the degree of proficiency which he attains in these lines, greater remuneration.

The ideal welder, one who can be depended up to satisfy the Classification Societies' requirements, differs very materially from our estimate of the average riveter as we meet the latter day by day. The characteristics which fit him for his work are as largely mental as physical and the work itself further develops his acuteness of mind, powers of observation, judgment and ingenuity.

As in other departments of shipbuilding, thorough mastery of the welding art cannot be obtained either through correspondence or so-called welding schools. It is just as necessary for a welder to learn by experience how to assemble and prepare his parts and to conduct the various finishing treatments, as to gain dexterity in drawing an arc.

The latter can easily be picked up while serving his apprenticeship in the former, hence my preference always to choose my welders from among the handy ship workers, boiler makers and forge shop helpers. These men have learned heat treatment and know how to handle tools and the degree of intelligence they show in manipulating the arc will indicate the measure of their success as welders.

The conditions which I have enumerated as the price of success may not appeal to the rank and file of the workers, as evidenced by our experiences of the past year or more, but I am hopeful that we shall shortly witness a reorganization of labor by which the better element may be divorced from the drones and those who have both ability and desire to advance, be left free to attain that eminence which is the due of every earnest worker.

WELDING DEFINED

The development of welded ships may be regarded as the obverse corollary of the elimination, or partial elimination of riveted work and the substitution therefor of welded jointures in the construction of marine vessels.

In my dealings with this relatively new art I have continually featured the word "jointure" as indicating the act of joining, or condition or being joined at a common point, a plurality of structural members.

Similarly, I employ the expressions "fillet weld," "butt weld," etc., to describe the mass of metal deposited as a progressive casting, for the jointure of a plurality of members into homogeneous mono-structures, as by welding, at their conjunctive edges.

These may be called "unified" or "unific" structures.

If further definition be required it should be understood that the fused weld material, *e. g.*, the weld, is in reality a casting and therefore has its limitations as to tensile strength, ductility and elongation. As we progress in our development of the art we shall no doubt learn to convert our cast steel or other metal welds into jointures of high ductility just as we learned, long ago, to convert our steel ingots into forgings.

The mere fact of our not having attained this proficiency in welding should not defer its progressive adoption for, even though we wholly ignore ductility and elongation in our catalog of virtues, its tensile strength and adaptability for multitudes of ships' jointures places it far in the lead of riveting.

By using welded jointures we obtain maximum strength with minimum weight of parts. We effect great savings in the construction cost by eliminating various processes such as templating, punching, riveting, chipping and caulking plates, slotting or notching beams and plates for inserts, shaping and forging difficult brackets and angles, and the many other operations akin thereto.

It is not claimed that the actual welding of plating joints is more rapid or less expensive than riveting but, considered as a whole, welded construction can be executed more rapidly and with less expense than the aggregation of operations which, together, constitute riveted construction.

By no possible means can a riveted joint be made stronger or more durable than the plate itself, neither can the loss of strength due to perforating a plate be regained, even in part, by filling the hole with a rivet.

With welding it is only necessary slightly to increase the area of section to obtain a joint having 100 per cent plus efficiency.

METHODS OF WELDING

In the development of welded ship construction it is already evident some one system must ultimately survive as the fittest of the many methods now offered for forming the joints.

First, we have the Forge Welding which has served its purpose through all the ages since the days of Tubal Cain.

Second: Oxy-Hydrogen and other Gas Welding, blow pipe puddling we might call it, used in various ways and degrees of efficiency for fifty years or more.

Third: Carbon Arc Welding, first introduced something over thirty years ago. By this process the current is carried through a carbon rod to within arcing distance of the plate and a separate metallic rod interposed in the field of the arc in such manner as to cause the plate edges and metallic rod to fuse together as a homogeneous weld. Like gas welding the carbon arc is more or less of a puddling operation and as such is relatively slow, limited in application and expensive.

Fourth: Thermit Welding, invented by Goldschmidt. This has a wide range of application and gives excellent satisfaction but, on account of having first to provide a mold for casting the weld its use in ship construction is rather limited.

Fifth: Electric Spot, or Compression Welding; also known as Resistance Welding, developed by Elihu Thompson. For ventilator cowls, stacks and other light plate work and for end butt welding railing rods spot welding is both rapid and efficient. It is not, however, suitable for heavy plating jointures first, because the intermittent spot welds have no advantage over rivets for water tightness, and, second, the frequent pulling away of one or more spots among a group renders the process too uncertain to risk its use for important structures. Moreover, the great weight of units, if employed in field work, would make the cost of equipment prohibitive and the size of generating station necessary for supplying the 100,000 or

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more amperes of current required for welding ½″ plates would likewise prevent its extended use.

Sixth: Metallic Arc Welding, first patented by a Russian in 1887. In its present highly developed state this system appears to meet every requirement of the modern shipbuilder excepting perhaps, the welding of hull plates under water. It is entirely feasible to weld bulkhead plates and other fixtures to the innner surface of hull plating below water line while ship is afloat and it excels both gas and carbon arc welding in that vertical and overhead seams can be perfectly *made* by any experienced operator. Moreover, with the possible exception of low ductility and elongation, good metallic arc welds are practically 100 per cent efficient.

Further than this it would not be possible, within the limits of a single paper, to discuss the merits of the systems I have enumerated and also give the attention to questions of construction which I know are of far greater interest to you as designers.

Before passing on, however, I desire to relieve your minds of any fears you may have regarding the possibility of danger due to grounding the ship for arc welding. There really is no danger, especially where direct current apparatus is used, since the strength of current carried by the welding leads seldom exceeds 25 volts.

THE ULTIMATE SURVIVAL OF WELDED CONSTRUCTION

In a contribution to the current number of *Marine Engineering* I made the statement that welding has really suffered most at the hands of certain over-enthusiastic friends who urged the building of structures much beyond the proper capacity of their organization and equipment.

Making haste slowly has proven particularly beneficial in the development of this new method of ship construction because it is enabling builders gradually to readjust their personnel and accumulate the necessary mechanical equipment.

These have been very necessary preliminaries which, fortunately, are being successfully accomplished and there now appears to be nothing in the way of attempting the larger problems beyond the organization of the welding staff. Will our shipbuilders rally to the new standard? Of course they will. Welded ship construction, as I said at the outset, is bound to survive as the fittest of our present known methods and, to repeat my preceding statement, the riveters and their allied operatives, will be welcomed to the welding ranks with every prospect of peace and profit to all who conscientiously endeavor to make good.

"PERMISSIBLE SHIP'S WELDING"

In their last official Circular (No. 1328) of October 6th, 1919, Lloyds' state that "proposals to electrically weld parts of a vessel other than those previously listed * * can be granted * * provided the arrangements proposed are considered to be satisfactory and the system of welding intended to be employed has been recognized by the Committee as complying with the prescribed regulations and tests."

In this connection I may add that Lloyds' present attitude toward welding is all that can be desired, as I think you must admit from the statement made to me less than ten days ago by Mr. H. J. Cox, Assistant Chief Surveyor for the United States and Canada, that they stand ready to accept electric welding for any and all portions of vessels building to Lloyds' classification provided, of course, said welding is done in accordance with the specification laid down in their circular of October 6th.

NOMENCLATURE

The development of a welding nomenclature and system of designating symbols occupied a very considerable part of the Emergency Fleet Welding Committee's attention during its war time activities and it was my intention to reproduce for you the various typical designs and symbols which they proposed should be standardized for general use.

My reason for not carrying out that intention is this: The briefest reproduction I have found of the so-called official nomenclature covers twelve 8″ x 10″ pages of pica type and small design sketches, and it seemed to me inadvisable to burden my story with a repetition of matter which has already been used by a number of catalog publishers.

Whether the Welding Committee's code will ever come into general use among marine draughtsman is a question owing to its very complex nature, but I have no doubt its adoption or discard will be automatically accomplished as a natural operation of our daily experiences.

It is my belief that a very limited nomenclature, with not more than three or four characteristic symbols, will meet every requirement of inter-communication between draughting room and shop. If the foreman welder can be given a simple yet definite direction as to the strength or pressure requirements, plus arrangement of structure usually found on drawings, he will no doubt be fully competent to properly interpret that direction and perhaps execute the work more efficiently than he would with a drawing so filled with symbols and legendary directions as to place its interpretation far beyond the capacity of any ordinary mechanic.

Every arc weld of whatsoever form may be classed as a *fillet weld* (F), *butt weld* (B) or a *plug weld* (P), as may be better understood by reference to Sketch Figs. 1 to 8 inclusive.

According to position these become *flat side* or *overhead welds* as, for illustration, in Fig. 1 the F welds are *flat* while at B is shown as an *over-head butt weld*. By turning Fig. 1 to the position shown as Fig. 2, B and F become *side welds* and F[1] an overhead weld.

By turning Fig. 1 still further to position as in Fig. 3, B becomes a *flat weld* while F is an *overhead weld*.

In Fig. 4 the B and F welds are differently combined to produce a *butt strap weld*, or *jointure*, yet no essential change need be made in the instructions required for the proper interpretation of shop drawings which are usually complete at least to the extent of showing the assembly of parts.

In Figs. 5 and 6 the *plug weld* (P) is introduced as a means of attaching angles or

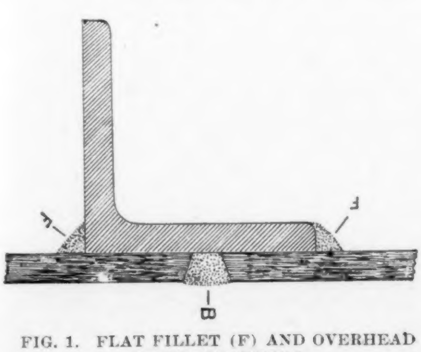


FIG. 1. FLAT FILLET (F) AND OVERHEAD BUTT (B) WELDS

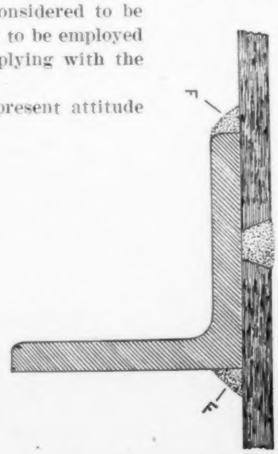


FIG. 2. SIDE AND OVERHEAD WELDS

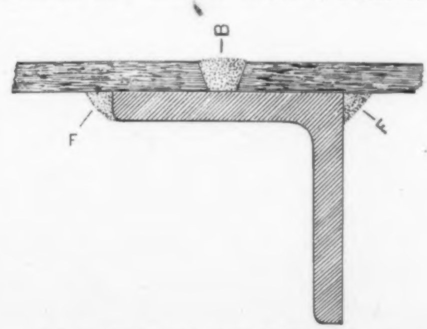


FIG. 3. FLAT (B) AND OVERHEAD (F) WELDS

other like members to plating. This form of arc weld is a cheap but very efficient substitute for riveting and does not require any perforating of plates.

Figs. 7 and 8 show another application of the F welds. If only one of the plate edges is to be welded, a single F can be used for its designation, but if both edges are welded the joint may be referred to in specification as FF and the symbol F shown against each plate edge on the drawing.

Further than above, it does not seem necessary to venture in the exploitation of symbolic directions for welding.

ELIMINATION OF UNNECESSARY MATERIAL

In conclusion let me suggest that in the preparation of drawings and shop orders for the fabrication of welded struc-

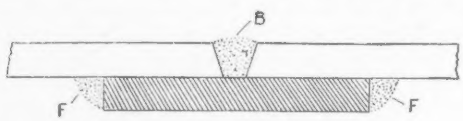


FIG. 4. BUTT STRAP WELD

tures the designer should keep constantly in mind the lesser dimensions of the plating required because of substituting open butt joints for the customary riveted laps.

He should also take advantage of the many opportunities for eliminating angles and other junction members so essential for riveted jointures but *wholly unnecessary in electrically welded seams*.

It is recommended that the designer consult freely with the welding engineer when developing the layout of new work as, between them, more efficient and economical results are secured.

A REVOLUTIONARY DEVELOPMENT

It should also be borne in mind that no holes are required in plating or shapes either for permanent jointures or assembling.

The latter operation is a special development of the welding art and its accomplishment emphasizes the possible elimination of the layer out, all operations accessory to riveting and the greater portion of all mold loft and template work.

Plates for the welded ship will be mill sheared to specification and templates furnished by drafting room, delivered direct to job and erected without further fabrication except in special cases requiring beveling or shaping.

By some these ideas will no doubt be considered revolu-

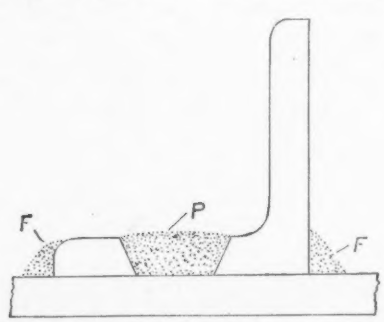


FIG. 5. SECTIONAL VIEW OF PLUG WELD

tionary in the extreme and yet, who among them all, can prove my statement wrong?

It is not many rods from this platform to that sacred spot where, less than a century-and-a-half ago, the greatest revolution in all history was confirmed and while that success may not stand as the godfather of all revolutionary propaganda promoted within the shadow of Independence Hall, my experience with welding prompts the belief that the present decade will witness the complete realization of my prediction.

ARCHITECTURAL REASONS FOR BARE HEADS IN THEATERS

MUCH has been written about the proper planning of an auditorium to secure good acoustics, which are even yet only too rare. But less attention has been paid to the securing of good visibility in lecture rooms and theaters. This is especially important in amphitheaters, in colleges, and medical schools, in which it is necessary for all the students to be able to see what is taking place upon the table in front of the professor.

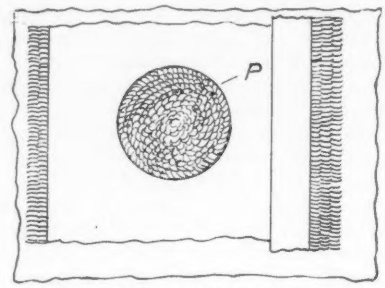
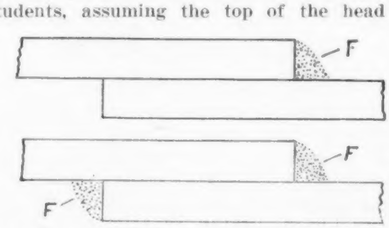


FIG. 6. PLAN VIEW OF PLUG WELD

This matter was recently made the subject of very careful study and extensive calculations, by an architect named Limongelli, resident in Egypt.

If we suppose the tiers of an amphitheater to be equidistant in plans then a geometrical tracing will show that the generatrix curve which passes through the eyes of all the spectators (supposing them for the sake of the argument to be all of the same size), will be a curve whose concavity is turned upwards and whose radius of curvature increases with the height of the seat. But the geometrical tracing of this curve, point by point, lacks precision, and, furthermore, it does not enable us exactly to determine *a priori* the height above the parquet of the highest seat in the amphitheater; but it is necessary for the architect to have such data in his possession when he is drawing his plans. Mr. Limongelli has succeeded in determining by calculation this magnitude, and while his figures are only approximate they are sufficiently precise for practical purposes.

He supposes three possible cases in the requirements of an amphitheater containing fifteen tiers of seats at a distance of 90 centimeters apart. If the audience is composed of bare headed students, assuming the top of the head be fifteen



FIGS. 7 AND 8. SINGLE AND DOUBLE FILLET WELDS

centimeters above the eyes, there will be a difference of 5.81 meters equaling the vertical height between the eyes of the student in the top row and the experiment table. If the students are placed not directly behind each other but alternately so that the eyes of each are opposite the space between the heads of the two persons in front of him, this difference can be reduced to 2.60 m. which is the minimum, but if, as is the case in Egypt, the auditors wear "tarbooshes" upon their heads, then the screen formed by the head of a spectator sitting exactly in front of another spectator, is 10 centimeters greater, and we find that the difference is increased to 8.85 meters which is a maximum. These mathematical facts indicate quite clearly the advantage of having the seats placed alternately and the importance of requiring all spectators to remove their hats, caps, turbans and other headdress.

Construction Work by Cement Gun Methods*

Certain Fields in Which the Pneumatic Method of Laying Cement Is of Special Advantage

By Arthur J. White

ONE of the most interesting mechanical devices that has been brought before the engineering world for some time, and one that gives the most promise of changing types and methods of construction, is the device which the general public first saw at the Cement Show in New York in 1910, under the name of the cement gun.

Carl E. Akeley, best known to the world as a hunter and naturalist, conceived the idea that by the introduction of water, or the hydrating medium, into the cementitious material coincidentally with the deposit, he could prevent the setting or hardening of the material before its application.

We, as engineers, can very readily see where this is a great advantage, but apparently Mr. Akeley saw more clearly than the average engineer the absolute necessity for this. He therefore conceived the idea of introducing the water into a chambered nozzle through which the dry material, previously mixed, should be forced by compressed air, and it is on this principle that the machine is based. As a matter of fact, compressed air to a cement gun is like gasoline to an automobile; it is the whole life of it.

Mr. Akeley's experimentation, carried on over a period of several years, showed the further advisability of dividing the material into small amounts, in order to prevent the clogging due to the introduction of too much material into the hose at one time. This resulted in the development of a method of intermittent feeding by means of a revolving feed wheel which allows the intermittent action necessary.

The next governing principle of this machine is that of the locking and working chambers of a caisson, thus accomplishing the result of a continuous operation, as the working or discharge chamber is always under pressure, the supply of material being introduced through the upper chamber.

The cement gun will thus be seen to be a pneumatically operated machine, dependent on the flow of air to obtain the desired results. This flow of air not only insures conveyance of the material to the nozzle, which may be located at a considerable distance and difference in elevation from the machine, but also the further beneficial result of having the material propelled by this pressure against the surface to be covered, thus insuring a permanency and density far in excess of any other method. In many instances, this means the elimination of heavy and expensive forms, for the material builds up against the backing to a considerable thickness without injury. It has been found that it is not advisable to apply more than two inches in one application as gravity will pull it loose.

In operating, the material is first mixed dry and placed in the upper chamber of the machine from which it travels in consecutive stages to the lower chamber, and thence through the hose to the nozzle. The water is introduced through the walls of the nozzle in needle jets under higher pressure than the air, thereby causing these jets to puncture this stream of flowing material. The action in the main hose causes the water from these jets to become atomized, resulting in the covering of all the particles with a fine spray.

When this hydrated material is impelled against the surface to be coated, the first effect is to cause a very marked rejection of material, which we call "rebound," which upon examination has proved to be sand, showing that the cement has adhered to the surface forming a film of neat cement which acts as a matrix. When this matrix assumes a perceptible thickness, the sand finds a seat or bed, and the rejected material, or rebound, grows markedly less. There continues a certain amount of rejection of this inert material, each grain of which, however, has performed the function of acting as a tamper to drive the preceding grains deeper into the matrix in which they are seated. The result of this pounding action is to produce a very dense, hard, and durable mortar which has been given the name of gunite.

*Abstracted from the *Proceedings of the Engineers' Society of Western Pennsylvania*, March, 1920.

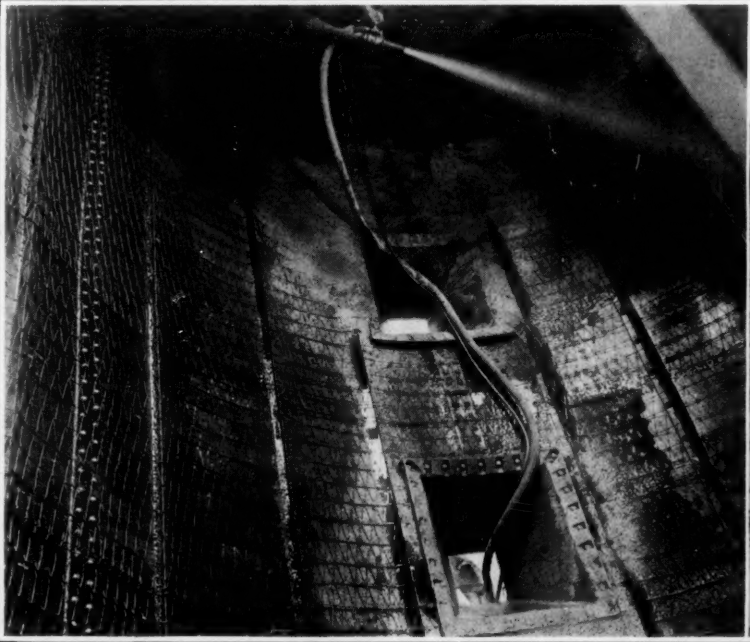


FIG. 1. LINING OF PARABOLIC COAL BUNKER WITH GUNITE

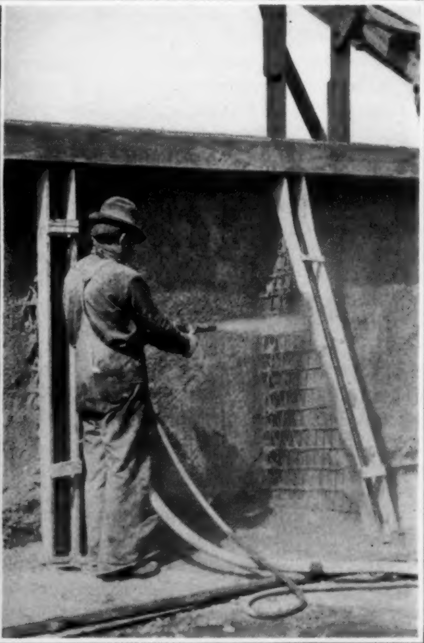


FIG. 2. COATING STEEL GIRDERS

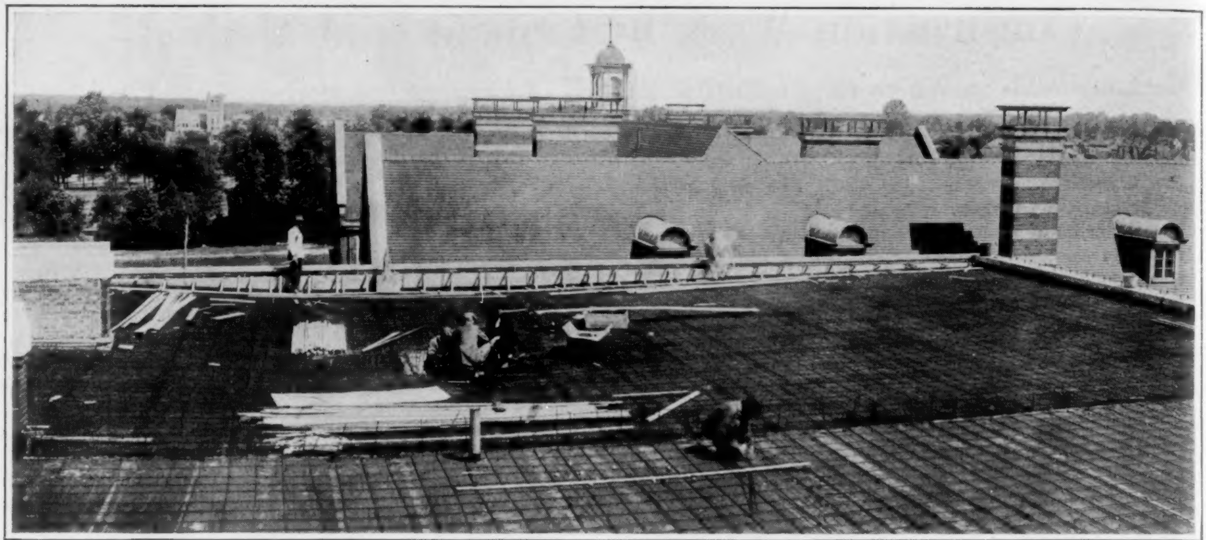


FIG. 3. ROOF CONSTRUCTION, FORD MOTOR COMPANY, DETROIT

Although this rebound has a definite and useful action, it also presents a difficulty which must at all times be reckoned with in order to insure proper and satisfactory results.

Different elevations and different work require different air pressures at the gun, and these figures are obtainable only through past experiences. When the correct air pressure has been obtained (the calculation depending on the class of work to be performed) it will mean that the impelled material must have sufficient velocity to result in the rebound being thrown back sufficiently to clear the reinforcing steel. If, on the other hand, the pressure employed is lower than it should be, this rebounding material lacks sufficient velocity and causes it to flow behind the reinforcing wire or steel and lie in loose piles forming what are termed as "sand pockets." Sand pockets are very serious and must be guarded against if successful work is to be executed. In cases where the material is shot into confined spaces, and under unusual conditions, great care must be exercised and methods developed to overcome this defect; otherwise, the work will result in a failure, since no fixed rule can be stated to overcome the various difficulties.

The cement gun method of construction offers several advantages to the engineer.

The material produced is infinitely stronger in all tests than any concrete or hand-placed mixture yet produced, thereby permitting a very considerable reduction in section.

In spite of the greater strength of the product, the cement gun method is not expected to supersede ordinary concrete construction for every purpose. It is too slow and too expensive for heavy work.

It has been proven beyond all doubt that the joint between the new and old sections of gunite is as strong as the gunite itself, and between old poured concrete and gunite it is stronger than the concrete. An interesting proof of this was developed on some work in Arizona a short time ago. A concrete girder was poured and allowed to cure for several days, after which a gunite knob was shot on the side of this girder, the surface, of course, having previously been cleaned and thoroughly wetted down. The top of this gunite knob was smoothed off to act as a fulcrum, and sufficient leverage was applied to break down the section. The break instead of occurring along the cleavage line between the gunite and the concrete took place within the poured concrete itself.

Fig. 2 shows the main deck girders of the track elevation of the Chicago, Rock Island & Pacific Railroad, in Chicago, at Seventy-ninth Street. All deck girders, floor beams, etc., on this job were incased with gunite. Owing to the perfect adhesion of gunite locomotive gases cannot attack the steel.

The commercial side of building construction is perhaps most interesting to us as engineers, however. Low initial cost sometimes makes a greater appeal to those contemplating building than does low ultimate cost. Some people are not able to foresee and calculate the cost of maintenance required on structural work. This state of affairs has, perhaps, been responsible for the wide use of corrugated metal for roofing and inclosing not only warehouses but various types of industrial buildings. Such material is short-lived unless thoroughly maintained by protective paint, and the necessity of annually renewing such protective applications piles up maintenance costs which, if added to the initial cost of the structures, would soon reach an amount greater than would have been necessary to build for permanence and eliminate these burdensome charges.

Fig. 1 shows the inside of a coal bunker. In the opinion of the author, this is one part of an industrial plant which is sorely neglected. Steel in coal bunkers receives a large amount of wear and tear, not only with wet coal and the sulphurous action on the steel, but also owing to the abrasive action of the coal on the steel. Several methods have been tried for preservation of this steel, but the author feels very safe in saying that the one that has been most successful and most economical is to line coal bunkers with gunite. Owing to its very density and its close adhesion to the steel, it can be readily seen that it is an excellent method of protection.

Another type of bunker construction which has been widely used is the parabolic bunker, hanging like a bag. When these bunkers are loaded to capacity, the steel conforms to the load, but with all the large number of instances using this style of bunker, I can truthfully say that we have never had any evidence of any breaking or cracking due to the elasticity of the steel.

There is also another type of bunker, different in design from the last two mentioned, and that is a patented bunker constructed of steel bands hung in parabolic shape, on which is fastened "hy-rib" or "ferroinclave." Several of these bunkers have been constructed with the cement gun, and in some instances the thickness of the coating has been as much as six inches. These have all proven very successful. Lining coal bunkers when first built is becoming quite a common practice.

The gas purifying tanks of the Peoples Gas Light & Coke Company, in Chicago, offer another interesting illustration. Owing to the enormous demand for gas, which in this instance is artificially produced, it was found necessary either to

construct 12 tanks to take care of their peak-load capacity, or in some way protect the 16 existing tanks so that an even temperature could be maintained. The author is not very well versed in chemistry, but believes that together with the iron oxid which is deposited inside those tanks, steam has to be injected, resulting in a chemical action taking place, thereby purifying the gas. During the extreme cold weather, it was a constant source of worry to the engineers to maintain an even steam pressure, which had to be kept up to 95 pounds, and, which I might add, constitute a very expensive item. Owing to the exorbitant price of steel and the scarcity of labor, the engineers looked around for some method by which they could protect these tanks from the extreme cold weather. The method adopted was as follows:

A three-inch cork insulation was first placed next to the steel on both sides and tops. This cork was held in place by cables, and hot pitch was applied to the joints. Over this was placed a layer of wire mesh, and gunite was then shot on to a thickness of 1¼ inches. The result was very gratifying as they could purify more gas in considerably less time and the steam bill was cut practically in half.

Fig. 4 shows a group of oil tanks at the Standard Oil Company's plant at Whiting, Ind. These were treated exactly as described above; but the idea of incasing these tanks was for the purpose of keeping the cold in, whereas in the previous ones the cold had to be kept out. The tanks contain the residue of crude oil which is put into a tank at a temperature of about 120 degrees. It then has to be frozen down to a temperature of 20 degrees, after which they take off polarine, vaseline, etc. To illustrate further the saving made by incasing these tanks it was shown in subsequent tests carried out that they could freeze down an 800-barrel tank in 24 hours; whereas, before this coating was applied, it took from 48 to 72 hours to freeze it—that is, during the summer months.

We now come to a problem which presented considerable difficulty, and the results obtained along this line with the

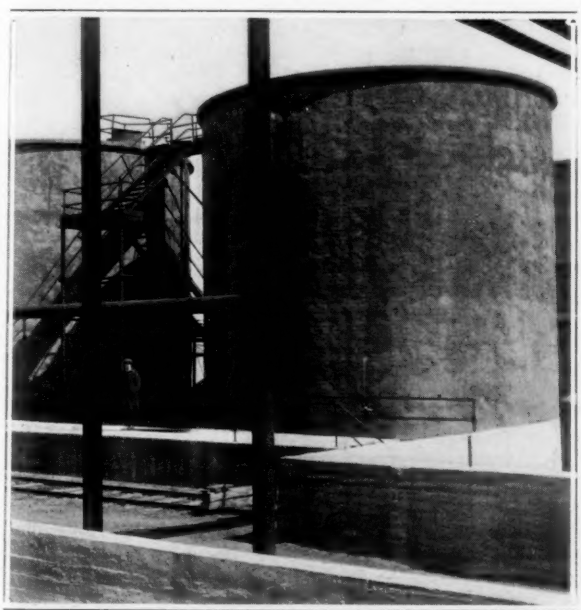


FIG. 4. TANK INSULATION, STANDARD OIL COMPANY WHITING, IND.

cement gun have been very interesting. I refer to steel protection in acid plants, and I have in mind a sulphuric acid house of the Mineral Point Zinc Company, at Depue, Ill. As can be imagined, the fumes from acid manufacturing processes were very destructive to the metal. The building itself was originally covered with corrugated sheet steel. At the end of 2½ years the roof had been entirely eaten away and the side walls were so badly corroded that immediate replacement became necessary.

Before commencing work, the entire corrugated metal roof and side walls were removed and the structural steel members were thoroughly cleaned of rust and surface oxidation by sandblast. American Steel & Wire Company's triangular mesh was stretched from girt to girt and a temporary backing of boards placed on the inside, spaced about one inch from the

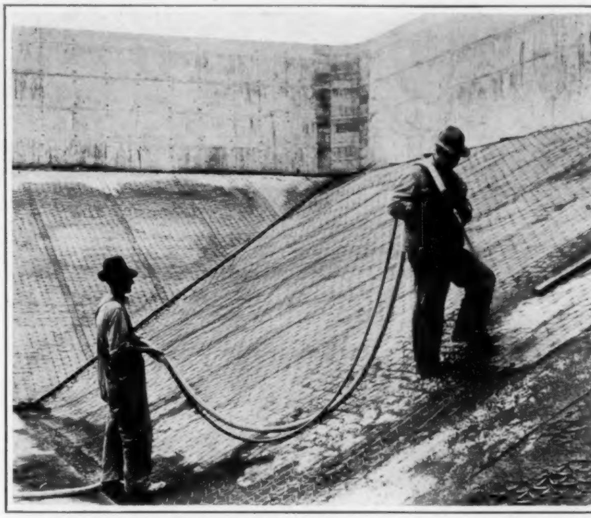


FIG. 5. PAVING A RESERVOIR AT MUSCATINE, IOWA

steel wire mesh. The wall was then built up to two-inch thickness by forcing the mixed materials from the cement gun against this backing and fabric. This work has stood long enough to prove that the walls are entirely weather-proof, and no cracks have developed as a result of temperature stresses. Poultry netting was wrapped around purlins and these were entirely incased with gunite applied so that the entire roof structure, including steel purlins, has been covered with what practically amounts to monolithic concrete. Where the corrugated metal on the sides was still intact, it was left in place and used as backing, wire was stretched over it and gunite shot through from the outside. Where the metal had been so badly corroded that it could not be used for backing, temporary forms were erected to answer the same purpose. The entire building was covered in this way. The cost in this case was only 50 per cent greater than the cost of replacement with the corroded metal. The advantages, however, lie in the fact that the structural steel will be protected against further corrosion and there will be no maintenance necessary to keep the structure in condition equal to that when the renovation was finished.

The first extensive job done with the cement gun was on the water storage reservoir supplying the town of Muscatine, Iowa, Fig. 5. This is a bowl with a concrete retaining wall on the top. Reinforcing wire mesh was spread over the slopes and the bottom. The whole area was given a two-inch coat of gunite, the retaining wall being coated to a thickness of one inch. In this particular instance the basin was constructed in five slabs, there being expansion joints only in four mitred corners, and along the line where the slopes and the bottom meet.

Gunite has peculiar characteristics of its own, and, providing that it is properly reinforced, we can practically ignore expansion and contraction. In my opinion it was wrong to put in the contraction and expansion joints, in the installation just mentioned. Take a slab of gunite, let it thoroughly cure, and then put a microscope on it, and you will see that it is split up into thousands of hair cracks, each of which penetrates to a

FIG. 6 GUNITE ROOF CONSTRUCTION, ARMY BASE, NORFOLK, VA.

depth of, say, 1/32 or 1/16 of an inch, and which do not take water. It is my opinion that the contraction and expansion of gunite are taken up by these minute hair cracks.

Another job where the cement gun was extensively used was on the Norfolk army supply base. It was a stupendous undertaking, which cost around $40,000,000. These terminals were built by the Government. They are situated on a site which is about six miles from the city of Norfolk, Va., on Hampton Roads, and cover about 640 acres. There are six warehouses, none of which is less than 1,400 feet long, and several of which are 1,680 feet long. The Government had the use of a vast area on the shores of Hampton Roads, and it built the warehouses at the army supply base on the horizontal plan, each one of the eight buildings being long and low and of only one story.

When beginning the construction of the Government warehouses at various points, in 1917 and 1918, the transportation system of the country was seriously congested, and construction had to be confined to the use of such materials and to the employment of such designs as would cause the least possible burden to railroad service. It was first decided to construct these warehouses of tile. The weight of eight-inch tile that would be required to build the walls proposed for this army base exceeded 16,000 tons. Since tile had to be hauled a considerable distance by rail, and sand was plentiful, it was decided to begin to build the warehouses of gunite. From this it will be seen that about three-fourths of the bulk and the weight of the material required for the gunite walls would consist of sand.

The construction of these warehouses consists of wooden frame; and wooden posts, 10 inches on centers, carried girts, caps, and roof joints. To the posts and girts there is secured 0.068 triangular mesh. Wooden forms were placed on the inside of the building about one-half inch away from the mesh. Gunite was then shot into place from the outside to a total thickness of two inches. This makes a two-inch reinforced concrete wall of great strength and density, with the wire mesh reinforcement nearly in the center. The total length of all walls formed by the cement gun method on this job is approximately 20,000 lineal feet, 16 feet high. The area is approximately 500,000 square feet. While the original order was placed for only one of the buildings, the first work done was so favorably regarded that the order was extended to cover all six warehouses, including also a gunite weather protection on the tile building mentioned above.

In addition to these warehouses, there were constructed two piers which extended into Hampton Roads a length of 1,280 feet. Each of these two sheds consists of one center bay and two side bays.

The center bay extends above the roof of the side bays to form a monitor. There is an outside wall extending from the top of the parapet down about 11 feet, below which is a continuous line of doors. On each side of the center bay, and extending from the monitor windows down about 12 feet to a point below the side bay roof trusses, are curtain walls acting as smoke deflecting walls and screens. The roofs of the side bays are of slow-burning wood construction, similar to the warehouse roofs. The center bays of these two piers, however, have gunite roofs. The roof structure over the center bay consist of I-beam purlins. Forms were placed between these I-beams snug up against the under side of the flange. The wire mesh was placed in continuous ribbons running between the eaves and supported on the wire chairs three-quarters of an inch above the I-beams, with a dip or camber of about one-half inch toward the center of the span. The thickness of the gunite is 2¼ inches. A test panel of this roof showed remarkable strength. With a uniformly distributed load of 164 pounds per square foot, there was a deflection of five-eighths of an inch, with slight cracking. The load was increased, and at 209 pounds per square foot the deflection was 1⅝ inches at the center, with many cracks perceptible on the under side; but, when the load was removed, the slab came back to its original position, with no damage perceptible on the top side.

Fig. 7 shows a steel stack of the pumping plant of the South Works of the Illinois Steel Company, South Chicago, Ill. Rather than tear down a steel stack—which was in condition requiring renewal—thereby causing a shut down of the pumping station, it was decided to use the cement gun in reconstructing the stack. By coating the outside with reinforced, cement gun concrete, a new self-supporting stack has been built up. The steel stack was 175 feet high and 9 feet in diameter. The reinforcing net work consisting of rods and triangular mesh was built up around the steel shell, and the gunite applied 18 inches thick at the base, tapering quickly to 6 inches just above the base and then gradually to 4 inches at the top. The heavy section at the bottom was applied in three layers, while that part above the base was applied in one operation. Square, twisted, reinforcing rods of suitable strength, depending on the section and the height, were placed vertically at varying distances as the work progressed.

An interesting fact in connection with the stack construction is that the concret was applied when the steel was almost too hot to touch with the bare hand. The intake or breeching extending from the side of the boiler house to the stack was also incased with a three-inch layer of concrete, while this breeching was so hot that water thrown on it boiled.

Of course where forced draft is used, and the temperature at the base of a stack is around 1,000 degrees F. some sort of insulating material, such as asbestos, must be used between the steel stack and the gunite sheath.

In a great deal of work carried out by the Illinois Central Railroad in the South, it has been found that wood borers, such as the teredo, will eat away piling on the inside. In seeking some method to protect this piling, the cement gun was suggested. It is necessary to protect only the portion of the pile which remains out of the ground, as these wood borers will not attack below ground level. These piles were driven

into place with a 3,000-pound hammer, with no injury to the gunite coating, and to the author's knowledge have been in place a matter of four years. In a recent letter, the bridge engineer of the Illinois Central Railroad stated that a minute examination was made of these piles, and that the wood borers had not succeeded in penetrating the gunite coating.

Mine shaft lining is another field where the cement gun is used, especially where the shaft is timber lined, and it is necessary to waterproof and fireproof it.

The cement gun has had many failures, and will continue to have, when inexperienced people try to use it on work that requires skill and technical knowledge.

I hope that the few illustrations incorporated in this paper will serve to show the advantages that may be gained through the merits of this machine and its products, by which a saving can be effected which will be impossible otherwise. By that, I do not mean to imply that the cement gun affords a cheap method of construction. It is quite an expensive plant, involving machinery that runs into thousands of dollars. Of course, there are a lot of instances in construction work in which it has proven cheaper than any other method; but, on the other hand, in some of its operations the work is very expensive. It takes trained men to get results. No engineer or architect would place a difficult piece of foundation work in the hands of a plastering contractor. It is the same with gunite, if you have any work to be done with the cement gun, consult someone who knows what a cement gun is; what it can do, and what it cannot do. There are many things it cannot do, and it is with these things that many engineers have failed and ultimately blamed the cement gun.

OXYGEN IN METALLURGICAL OPERATIONS

THE United States' present production of oxygen is about 3,000,000 cu. ft., or say, 130 tons, per day, over 95 per cent of which is probably used in torches for cutting and welding purposes.

One-quarter of this produced by electrolysis comes from several hundred privately owned plants. The remaining three-fourths of the supply comes from about 50 air liquefaction plants.

The largest single installation for air separation ever erected was in connection with the cyanamide nitrogen fixation plant built for the Government at Muscle Shoals, Alabama, during the war. It was built primarily to secure nitrogen, but if operated at full capacity for oxygen would be just about equal in output to this country's total production as given above, and this in turn is just about equal to 1/5 of the amount of oxygen contained in the air blown to one full sized iron blast furnace making approximately 500 tons of iron per day. The United States' average daily production of iron last year was equivalent to that of about 170 such furnaces running every day in the year.

The cost of producing oxygen by electrolysis from water is about $12 per ton. In the separation of air, on the other hand, there is no chemical combination to overcome. The oxygen and nitrogen simply dilute one another. Due to their mutual dilution, however, their partial pressures in the mixture are only 1/5 atmosphere for the oxygen, and 4/5 atmosphere for the nitrogen and as when finally separated they must both have been compressed up to one atmosphere, we must do at least this much work upon them which amounts to about 60 hp. hr. per ton of oxygen produced, or only about 1 per cent of that theoretically required by the electrolytic process, the by-products being in the one case 3½ tons of nitrogen and in the other ⅛ ton of hydrogen.

The most important way in which enrichment of blast may essentially influence blast furnace temperatures is indirectly by allowing variations in composition of charge, e.g., making of ferrosilicon or ferrochrome directly in the blast furnace. Another important effect of the enrichment of the air would be the higher calorific value of the blast furnace gas obtained as a by-product due to elimination of part of its nitrogen.

The open-hearth presents some of the most interesting possibilities for the application of oxygen. With an open-hearth using ordinary air in order to reach the highest temperatures now attainable, a complete and carefully balanced combustion of gases must be secured resulting in a neutral or slightly oxidizing atmosphere, whereas if part at least of the furnace's burden of inert nitrogen could be removed the same temperature could be reached while still leaving a residue of unburnt material in the gas thus producing a strongly reducing atmosphere. By enriching the air the total volume of gases passing through the furnace per unit of fuel burned and heat produced may be cut down enormously, since in the air there are four volumes of inert nitrogen to every volume of useful oxygen. This would greatly facilitate heat exchange and reduce mechanical difficulties such as dust losses, maintenance and control of draft and the like, or on the other hand permit of speeding up the furnace and thus increasing its daily output.—Abstract from an article by F. G. Cottrell in *Chemical and Metallurgical Engineering*, July 14, 1920.

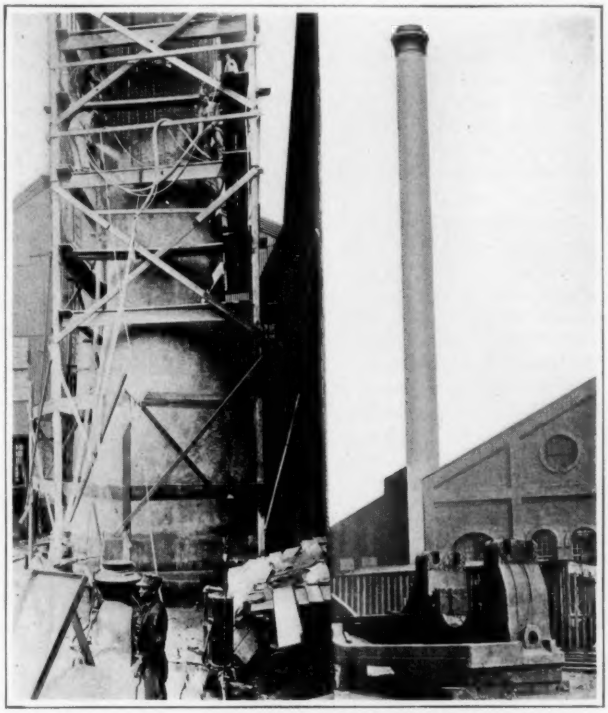


FIG. 7. GUNITE STACK, ILLINOIS STEEL COMPANY, SOUTH CHICAGO, ILL.

PUNCTURES IN CONCRETE HULLS

AN editorial in *Engineering News-Record* of July 22nd, 1920, refers to the tendency to puncture as the most serious defect of the concrete ship. The fact that repairs can be made very easily and quickly has been advanced as an argument in favor of concrete for ships, but concrete vessels cannot stand the blows that wooden and steel hulls commonly experience without damage, so that the ease of repair is offset by the frequent necessity of such repairs. The greater weakness of ship concrete over concrete structures on land may possibly be due to the peculiar nature of the former with its rich mix and closely-spaced steel. Furthermore no land structures are ever subjected to the forces that concrete vessels experience in a heavy sea.

Solid vs. Pneumatic Tires*

Their Relation to Motor-Truck Efficiency in Various Classes of Service

By S. V. Norton

IN an excellent paper, entitled Pneumatic Tires for Trucks, by B. B. Bachman, read before the Society February, 1919, the principal advantages and disadvantages of pneumatic-tire equipment were set forth clearly and forcefully. In my judgment, his paper is the most convincing presentation of this subject that has yet been made. Notwithstanding the apparent limitations of the economical use of pneumatic tires due to external factors, so much has been claimed in their favor since his paper was written that it seems advisable to analyze the relation of both solid and pneumatic tires in respect to their effect upon motor trucks in practical operation.

A distinction is here made between the inherent "ability" of a truck to overcome road friction and the force of gravity due to its engineering design and its ability to deliver merchandise economically under a given set of external conditions. It is largely in the latter sense that I shall discuss the subject, although I realize that the members are perhaps more especially interested in the former. In the last analysis, however, trucks must be designed and built to meet the needs of their buyers, who use them to move freight under widely differing and complex circumstances.

Viewing the problem from this angle, I have sought information not only from truck manufacturers and their engineers, but from truck salesmen and operators in all parts of the country, as well as from tire dealers and those upon whose local service in the field the continued and successful operation of the truck depends. The information presented is not theoretical, nor based upon the experiences of selected operators whose delivery problems would invariably point to the same conclusion, but is rather a composite of the opinions of hundreds of truck operators engaged in handling all kinds of merchandise, and of hundreds of men whose business it is to help keep those trucks running economically. Because of the concentrated study that is being given to all phases of motor transportation, some factors in the problem are almost as variable as a kaleidoscope. Hence, conclusions which may appear sound today may have to be modified by changes that are gradually but constantly taking place. For instance, truck design is being altered and improved. Tires are being built better and stronger. Roads are being improved, while experience is pointing the way to the more intelligent use of motor trucks through systems and devices heretofore unknown. It therefore seems worth while to view the question of truck tire equipment in the light of recent experiences of many operators and service men, to get a clear idea of the advantages and limitations of each type.

GENERAL FUNCTIONS OF TIRES.

The functions of tire equipment are: To secure traction, cushion the mechanism and the load and protect the road. From the truck operator's viewpoint the first two are of more importance than the third, although it is becoming increasingly necessary to safeguard the taxpayers' investment of millions of dollars in improved highways through proper restrictions upon the vehicles that use them. To perform these functions, solid, cushion and pneumatic types of tire are available. The general knowledge of the construction and peculiarities of each type makes it unnecessary to describe them, except to say that the cushion tire is in reality a solid tire, usually made from a specially resilient rubber compound, so designed in contour or internal construction as to be soft and yielding under pressure. Its construction generally renders it less rugged and hence more susceptible to early failure under severe service conditions. Since there are relatively few cushion tires in service at present, we may profitably confine our discussion to the solid and pneumatic types.

At present the accepted field for pneumatic tires is on trucks up to 1½ tons capacity, and for solid tires it is on trucks of 3½ tons or over. Between these two capacities the field is debatable, and the choice cannot be made intelligently without a careful analysis of the important factors involved in each individual case. If the operators of trucks in this debatable field could surely avail themselves of all the advantages claimed for pneumatic-tire equipment, no trucks would be found on solid tires, since the claims embrace nearly everything the truck owner desires. Let us review the claims made on behalf of the tires themselves and then study them in relation to various external factors which should have an equal if not greater bearing upon the choice of equipment.

From several hundred truck-tire salesmen, as well as truck operators throughout the United States, whose opinions were asked as to the principal advantage to be gained from the use of pneumatic tires in the debatable field above described, the following table shows the reasons given with the percentage of replies for each:

	Per cent
Greater traction	40
More cushioning	28
Higher speed	21
Lower repair bills	5
Saving in gasoline	4
More work possible	2
	100

Other reasons were given for the use of pneumatic tires, but they were thought to be of secondary importance. They were

(1) Less breakage of loads
(2) Reduced fatigue of drivers
(3) Less depreciation of trucks
(4) Reduced depreciation of roads
(5) Adaptability of trucks to farm use
(6) Lighter weight trucks possible
(7) Increased earning power

DECIDING FACTORS IN TIRE CHOICE

It is apparent that a careful study should be made of all the factors involved before deciding which type of tire to use. For the purposes of this discussion the factors may be divided into three groups: engineering features, practical operating features and features of tire service in the field. In taking up the engineering aspects I speak briefly and frankly as a layman and not as a truck engineer. Before changing tire equipment from solid to pneumatic it should be realized that to gain certain possible advantages other definite disadvantages must be faced. First, the wheels of the vehicle must be cut down to receive pneumatic tires. The cost of this will vary according to local conditions, but it is a large item of expense. As the pneumatic tire has a larger actual than nominal diameter, and since in many cases a pneumatic of larger nominal diameter must be used than is required for a solid tire, to secure the necessary carrying capacity, proper allowance should be provided for both body and fender clearance. It should also be remembered that the larger sectional diameter of the pneumatic tires will affect the steering clearance and that the truck will be unable to turn in so short a radius as it did on solid tires. This is especially important

*Paper read before the Chicago Truck and Tractor Meeting of the Society of Automotive Engineers.

in negotiating turns in narrow streets and alleys, as well as in garages with limited floor space. As the larger diameter of the pneumatic tires will affect the gear reduction, the change will have a corresponding effect on the mechanical ability of the truck. If the change is made, will the truck be able to "make the grade" so far as particular problems are concerned? Will it materially affect the pay-load capacity of the truck? Will it reduce ability to carry trailers? What will be the effect upon the engine?

The increased maximum speed due to the larger diameter of the pneumatic tire will be relatively slight, provided the engine is governed to run at the same speed as formerly. If the change is made to get more speed, either the gear ratio must be reduced and the ability of the truck thus still further reduced, or the governor must be opened and the engine speed increased. There is danger here, however, as speed induces extra vibration, joints begin to loosen and before long the engine may be literally racked to pieces.

As the engines in some trucks now have pressure-feed oiling systems, they can more safely withstand the extra speed, so far as lubrication is concerned, although this feature should be carefully investigated, as there is danger of damage from this cause with resultant expense. Still another factor which should be considered is the tax upon the cooling system if the engine is speeded up. Again, additional speed calls for greater braking ability. Before changing tire equipment assurance is necessary that with increased truck speed and the limitations imposed on the diameter of the brake drums by the reduced diameter of the wheels themselves, the machine will still have sufficient braking ability. Brakes designed for slower speeds but used under more severe conditions, will inevitably require more frequent renewal and may not even safely perform their required function. In fact, an engineer of one of the larger tire companies, advocating the use of pneumatic tires on trucks, says:

"On account of the comparatively high speed of the pneumatic-equipped trucks, it is necessary to equip them with brakes having 100 per cent more capacity than is the case with solid-tired trucks."

The question for decision is whether or not the truck can be so equipped and, if not, whether it can be safely operated on pneumatic tires.

Of no less moment than the features already mentioned, so far as the dependability of the truck is concerned, is the question of the air supply, since pneumatic tires may require from 90 to 160 lb. per sq. in. inflation pressure. As hand pumping is out of the question, a power-driven pump on the truck, or one close at hand, becomes a necessity. Relatively few trucks now running can properly accommodate a power pump. With a transmission arranged so as to permit of power take-off, a pump attachment can be put on. If the transmission is mounted amidships, it is possible to provide a device to take power from the drive shaft. If, however, the truck has its transmission in a unit with its engine, with no provision for power take-off, there appears to be no satisfactory way of attaching an air-pump, since the magneto and water-pump shaft is generally too light for power take-off. There is, of course, the possibility of adapting an electrical system for this purpose, but this does not seem practicable, because of its cost and the fact that such apparatus is not standard practice.

While these mechanical considerations apply particularly to trucks now in operation on solid tires, most of the same problems are involved in changing the equipment on trucks manufactured but unsold. The buyer usually looks to the agent for advice regarding tires; he should therefore satisfy himself that the agent's counsel is based upon positive facts and endorsed by the manufacturer. Otherwise, more or less disappointment and dissatisfaction over the performance of the truck can be expected if the tire equipment is changed to pneumatic before delivery. To sum up, since so many important technical features are involved, it is well to seek the advice of the truck builder before changing equipment from solid to pneumatic tires. No one else knows so well the probable effects on various parts, nor can anyone advise more intelligently as to the probable loss or saving that such a move would entail upon the mechanism of the truck.

Let us next consider the practical operating features that must be taken into account in determining which type of tire equipment will make the truck most efficient in service. Broadly speaking, the efficiency of a truck in performing its function depends upon the amount of time or money, or both, that it saves for the shipper, as compared with any other means of haulage. While it is difficult to separate all the factors bearing upon these two items, they may be roughly classified as follows:

Factors Affecting Time	Factors Affecting Cost
(1) Distance of hauls	(1) Amount of pay-load and overload
(2) Traffic congestion	(2) Condition of roads; effect on tires and truck
(3) Speed of delivery	(3) Number of trips per day
(4) Regularity of delivery	(4) Cost of operation
(5) Conditions of roads; effect on speed of truck	(5) Cost of upkeep
(6) Number of trips per day	(6) Cost of substitute equipment
(7) Time out for repairs, etc.	

The question of how tire equipment bears upon these factors can only be answered after careful analysis of each particular case. However, certain principles can be applied to all cases. To begin with, from 75 to 225 per cent more must be paid for pneumatic than for solid tires. The latter figure includes the cost of spare tires, which are indispensable at the present stage of development. So far as is known, there are no dependable figures indicating the relative cost per mile of the two types, because pneumatic truck tires have not been used long enough to make reliable comparisons. From such information as is obtainable, however, it is my belief that it will cost from two to three times more per mile to run on pneumatic than on solid tires. To offset this increased cost there should be a corresponding or greater saving in one or more of the factors already enumerated, as affecting the operating efficiency of the truck.

HOW TIRES AFFECT TIME FACTORS

Let us now inquire how pneumatic tires may affect the time factors, assuming that the mechanical features of the truck are such as to permit of their use. If the truck is engaged in long-distance hauling with relatively few stops, pneumatic tires will almost invariably save running time, due to the fact that they absorb the road shocks so much more easily than do solid tires. By theoretical tests in our laboratory we have found that, for a given load, pneumatic yield over four times more than solid tires. Hence a truck can be driven over long distances at much higher speeds on pneumatic than on solid tires without fear that it will be racked to pieces. It should also be noted that the drivers' fatigue in such cases is far less on pneumatic than on solid tires. In fact, some operators have considered this so important that they have placed cushions with special springs in their drivers' seats.

Up to the present, however, very few trucks as compared with the total number in operation, certainly less than 5 per cent, are engaged in long-distance hauling. The great majority of trucks operate in cities where traffic congestion is such that they cannot possibly attain a speed of over 10 m.p.h., while their average speed is from 5 to 9 m.p.h. For such speeds there is no possible saving in the list of time factors to offset the extra cost of running on pneumatic tires. Moreover, the gain will be still further reduced by idle time at loading and unloading points. In many cities an effort is being made to reduce the maximum legal speed at which trucks may operate because of the many serious accidents

attributed to them. Hence, increase of driving speed within city limits may be prevented by ordinances limiting the speed of trucks. Light delivery vehicles, running on pneumatic tires, are sometimes operated at higher speeds than are legal, but these do not properly come within the "debatable field" and are not considered as dangerous as the heavier vehicles.

In certain kinds of business such as the wholesale delivery of milk, gasoline, ice, etc., the regularity of service is the most important factor. Here the use of heavy-duty pneumatic tires is fraught with danger, due to the possibility of delays caused by punctures and poor tire service. Many operators in these and kindred lines have said that it is more important to deliver goods regularly and on time than to save a few dollars on truck upkeep. Failure in this means loss of the customer. One large truck-fleet operator in this group uses no pneumatic tires of over 6-in. section because solid tires or some good make of cushion wheel have always given him greater satisfaction at less cost than have larger pneumatic tires. Such equipment usually lasts for more than two years without trouble.

The condition of the road surface has a very important bearing upon the time element, for it has a direct effect upon the truck speed. In fact, under certain circumstances, the increased traction afforded by the heavy-duty pneumatic tire makes it possible to operate the truck, while if it is equipped with solid tires it cannot be driven at all. This is particularly noticeable in rural districts where there are no hard-surfaced roads.

In the farm lands and citrus groves of the South, where there is so much sandy bottom and so little surfaced roadway, it is practically impossible to operate a truck equipped with solid tires. However, a truck equipped with heavy-duty pneumatic tires can operate practically anywhere and is not dependent upon the highway for traction. Under such circumstances, the ability gained by the use of the pneumatic tire is worth 100 per cent more than that of the solid tire, no matter what its cost, for the latter is well-nigh useless. It must not be supposed, however, that there are no circumstances under which pneumatic tires will fail to perform their function unassisted by anti-skid equipment. The need for proper tire and chain clearance in changing from solid to pneumatic tires is again apparent, for, if due provision is not made, the time factor may occasionally be seriously and adversely affected.

One of the advantages most frequently mentioned is the greater number of trips per day which can be obtained from a truck equipped with pneumatic tires. So far as this factor alone is concerned, there is no doubt that the advantage is in favor of the pneumatic tire.

One more important factor affecting the time element is the number of hours the truck is laid up for repairs. Let us consider separately the time lost on account of tire trouble and that for all other reasons. In comparing the relative amount of time out for tire trouble for solid and pneumatic tires, the advantage lies wholly with the former. Barring occasional lay-ups caused by defective material or workmanship, solid tires can be depended upon to give uninterrupted service from the time they are applied to the time they have worn down to the renewal point. An appointment can then be made in advance with a tire service station without seriously disturbing regular truck service, and the worn tires replaced with new ones. There is hardly a sizable city in the United States that does not have one or more hydraulic presses for this purpose and well-equipped service stations with ample stocks of solid tires. It is therefore only a question of laying up the truck a few hours at rare intervals, which can be planned so as to interfere very little, if at all, with the regular use of the truck. While the condition of the roads over which the truck operates influences to a certain extent the mileage delivered by solid tires, and hence the frequency of lay-ups for renewals, this factor is far less important for solid than for pneumatic tires.

Owing to the comparative vulnerability of pneumatic tires, they are far more likely to require time out for repairs and replacements. In the first place, they cannot withstand the same amount of overloading as solid tires, and when they are overloaded they are especially apt to give out. Such "failures" usually occur when the truck is in action and away from a service station. If the operator has a spare tire he may make the change on the road, although the evidence seems to indicate that it requires a skilled mechanic to do this and that it cannot be done easily or quickly. Most operators of trucks find it impossible to change a tire in less than 1 hour under best conditions; under bad conditions it requires 2 or 3 hours. Punctures do not seem to be so frequent or so costly in point of time as blow-outs due to cutting and chafing of side walls from ruts, as well as to underinflation and overloading. While solid tires are cut and torn by ruts, they are not so dangerously weakened by the process, and they rarely give out unexpectedly. If regularity and dependability of service are sought, these will be far more likely to be secured with solid rather than with pneumatic tires.

In comparing the time out for causes other than tire trouble, we find a variety of conflicting claims, although it seems to me the evidence favors the use of pneumatic tires. On the other hand, some claim that the use of pneumatic tires accelerates the wear of certain parts such as bearings, bushings and steering knuckles and that a correspondingly greater amount of time is required for their adjustment and renewal. Moreover, many owners state that the use of pneumatic tires on trucks causes their drivers to overspeed and to take more dangerous chances that result in accidents and time out for otherwise unnecessary repairs, than is the case with solid tires.

HOW TIRES AFFECT COST FACTORS

In discussing the factors affecting the time element I have purposely avoided reference to the cost of the time, although I realize that these items all have a relative money value. In turning to the factors affecting the saving of money, it will therefore be necessary to refer to that aspect of some of the time features already mentioned. Moreover, although the two are so closely related that it may be difficult to distinguish between them, let us next consider the effect of solid and pneumatic tire equipment on the various money factors involved.

The amount of work a truck can perform, and hence the saving or profit it will show, depends largely upon the amount it can carry, or its pay-load. It is generally held that the more the truck carries, the more it earns or saves. The result of this belief is the well-nigh universal tendency to overload trucks beyond their rated capacity. In fact, many operators maintain that they cannot use trucks profitably unless they overload them. I shall not here attempt to debate the wisdom of this philosophy, but in analyzing the problem the fact must be faced that nearly all operators do overload their trucks and there seems to be no simple or effective way to prevent it. It is not uncommon to find trucks carrying twice their rated capacity.

When it comes to durability under this usage, there seems to be no doubt that solid tires will not only carry heavier overloads but will last longer in such service. All agree that the life of the heavy-duty pneumatic tire is short when overloaded. This seems the most important and least understood factor in the entire list. Apparent savings may be offset or overbalanced by the additional trips that become necessary when an overload cannot be carried. The use of pneumatic tires automatically places a lower limit upon the pay-load which can safely be hauled under *any* conditions.

Closely allied to the cost of overloading pneumatic tires is that of underinflation. In this case the constant and extreme flexing has a tendency to weaken the side wall, making it much more likely to fail in service. It is held that drivers should give the same attention to tires as they give to water

in radiators, oil in engines or gasoline in tanks. This is only another way of saying that the driver must be careful not to abuse his truck. Those who employ drivers realize how difficult it is to get men to watch these details, and the fewer such points requiring the driver's care and attention the more likely it is that the truck will run continuously and economically. While solid tires are not invulnerable, they are more nearly fool-proof and less expensive to maintain in working condition.

In addition to the likelihood of incurring expense from overloading and underinflation, there is the danger of ruining pneumatic tires from running them when loaded or overloaded after they have been punctured or blown out. It is not uncommon for drivers to ruin practically new tires by not stopping trucks as soon as tire trouble is suspected. A single blowout or puncture under such circumstances may cost from $25 to $100.

The condition of the roads over which the truck travels not only affects the speed or time factor, but has an important bearing upon the life of the tires and hence upon their cost. Pneumatic are subject to more damage than solid tires when run over roads with deep ruts because of chafing and cutting of the side walls.

In attempting to collect data as to mileage on pneumatic tires, many varying claims and little information based on records of a dependable nature were found. Operators are apt to exaggerate both high and low mileages, due to personal satisfaction or disgust, as the case may be. Most operators when questioned closely regarding averages will admit that they have not used pneumatic long enough to obtain reliable figures for comparison with solid truck tires. Hence, none but general conclusions are possible at this time. The mileages reported, from Maine to California, varied from 200 under adverse conditions such as bad roads, overloads, careless drivers, etc., to 25,000 miles on lighter trucks, over good roads and with proper care. Tires in city service usually give better mileage than those in use in the country. With rare exceptions the mileage delivered by solid is considerably greater than that from pneumatic tires in the same class of service.

Where the earning capacity of the truck is concerned, as judged by the number of trips per day, the advantage seems to lie with pneumatic-tire equipment, provided the runs are long enough and not restricted by such factors as traffic congestion and delays at terminals. In most cases the increased speed made possible by pneumatic tires can be converted into greater earning capacity, with little or no increase in overhead expenses.

As before suggested, there are certain conditions under which trucks on pneumatic can make trips when those on solid tires cannot be operated. Hence their earning capacity is just so much greater. But a new and interesting argument has recently been advanced on behalf of pneumatic tires, due to certain changes in the conduct of the business of farming. The ever-increasing use of gasoline engines for tractors, threshing machines, etc., requires the delivery of gasoline and oils direct to the farmers' door or barn. Oil men who own their own trucks and work on a purely commission basis frequently find it necessary to drive through the farmers' barnyard. It has been noted that trucks having pneumatic not only negotiate the unpaved roadways more easily, but do less damage than those having solid tires, and hence are looked upon with more favor by the farmers they serve.

When considering the relative effects of solid and pneumatic tires on the cost of operation and upkeep, a wide variety of opinions are expressed but very few conclusions based upon accurate cost records. In every other kind of business an intelligent analysis based on cost figures is considered necessary in arriving at conclusions. But few truck operators have yet realized the value of such records as applied to the cost of operation and maintenance of trucks. Hence the reliable data available are meagre.

Let us briefly examine the items which should be included in such costs, and consider how they are affected by solid and by pneumatic tires. The following items are usually not affected by tire equipment:

(1) Interest on investment
(2) Insurance
(3) Taxes and license
(4) Garage
(5) Supervision
(6) Wages of driver
(7) Wages of helper

Those shown below may vary according to the type of tires used.

(8) Depreciation
(9) Gasoline
(10) Oil
(11) Tires
(12) Repairs due to (*a*) wear and (*b*) accident

Considering these in the order given, there are, so far as known, no dependable figures covering depreciation upon which to make comparisons as no trucks have been run long enough on pneumatic tires to determine their effect on the ultimate life of the truck. While there is a difference of opinion among engineers, most maintain that the increased engine speeds of trucks designed for use on solid but changed to pneumatic tires will tend to wear out all moving part more quickly than if the tires had not been changed. As to the relative consumption of gasoline and oil, very few reliable figures are available, but the best informed operators are inclined to feel that there is little if any saving in these items, particularly on short hauls. On long hauls, however, the advantage seems to lie in favor of pneumatic tires.

When it comes to cost of tires there is no question. The cost of pneumatic averages from two to three times that of solid tires. This is due to the higher initial cost of the equipment and the spare tires, their greater susceptibility to abuse and accident and their lower average mileage. It is, of course, possible to have pneumatic tires repaired and re-treaded, but this process has not yet been satisfactorily worked out for solid tires, at least to the point that is considered dependable or economical. The question of tire service, however, including all these features, will shortly be discussed.

TRUCK REPAIRS.

So far as the cost of truck repairs is concerned, comparative data of a reliable nature cannot be obtained, for in most cases trucks equipped with pneumatic tires have not been used long enough to make satisfactory comparisons. The evidence indicates, however, that, excepting the engine, repairs will cost much less for trucks using pneumatic than for those using solid tires, due to reduced vibration. If the engine is not run at excessively high speeds or continually overworked, it will prove less subject to damage if pneumatic tires are used.

Dependable figures cannot yet be obtained on the relative cost of renting substitute vehicles to replace trucks using pneumatic and solid tires which have been laid up for repairs. A superintendent of a large truck fleet using both types states that he lays up solid-tired trucks four times a year for overhaul, while pneumatic-tired trucks are laid up only three times. In any event the variation in this item of expense will not be large, provided the trucks are carefully inspected and maintained.

Summing up the factors affecting the saving of time and money, the conclusion is reached that no general claims in favor of pneumatic-tire equipment on trucks coming generally within the debatable field can be substantiated, and that the work to be done by each specific installation must be analyzed carefully before either type of tire can be safely considered the more economical.

Having reviewed the engineering and practical operating features, let us now enumerate the operator's difficulties concerning tire service. As the nature and extent of service for the maintenance and renewal of solid tires are well known,

it seems unnecessary to comment upon them except to say that years of study and competition have developed this end of the business to a high degree of perfection, so that many well-equipped service stations can be depended upon for instant attention, in many cases by day or at night, whenever it is needed.

The manufacture of heavy-duty pneumatic tires of 6-in. section and larger is, however, a relatively new development. Less than a third of the manufacturers of passenger-car tires have actively started to make heavy-duty pneumatic truck tires, for they realize that the job of building a tire which will stand up under present-day use and abuse is not easy. Moreover, the task is not finished when the tire is removed from the heater. It must be sold to the dealer who, in turn, must not only guarantee the tire, but must place himself in a position to give the truck operator service. This means that he must install a high-pressure air-pump, repair material, molds for vulcanizing and in most cases a service car for emergency calls, for it must be remembered that the pneumatic tire is apt to fail when distant from its base and it cannot be driven home flat. Broadly speaking, to give service means doing whatever is necessary to keep tires in fit running condition. Specifically, it may be divided into three divisions: (*a*) inflation; (*b*) changes and renewals, including adjustments, and (*c*) repairs.

It can be said without fear of contradiction that the tire companies themselves are not as yet prepared to give really efficient service in all parts of the country. In fact, even in the principal cities this phase of the business has not been fully developed. In the smaller towns there are almost no air-tanks or pumps to keep tires properly inflated. Pumps on trucks themselves are reported as not always dependable, sometimes requiring from 15 to 30 minutes to secure the desired tire-inflation pressure. Some truck operators have ventured to use pneumatic tires even though they have no pump equipment. One such operator uses a hand pump to put in 60 to 70 pounds per square inch air pressure. This allows the truck to be driven slowly to the nearest power pump with sufficient capacity to get the necessary pressure. A second, who has no air-pump on his truck, says he cannot afford to carry spare tires because they use too much space. If caught on a long country trip, he waits until a service car arrives and provides proper tire inflation. Another operator who has a large truck fleet equipped with pneumatic tires keeps a light service car continuously busy carrying tires or compressed air to trucks experiencing tire trouble. A fourth encountered trouble with his demountable tire equipment which he had for a long time carried under heavy inflation. It had then become smaller in inside diameter and could not be put upon the rim. The need for rust-proofing rim parts to facilitate changing has been pointed out to the tire manufacturers. It has also been suggested that if possible the tires should be made lighter in weight as the larger sizes are very difficult and awkward to handle.

TIRE REPAIRS

By far the most serious and difficult phase of giving service with heavy-duty pneumatic tires, and that which causes the most concern to truck operators, is connected with their repair. In fact, the chief complaint in regard to pneumatic truck tires, aside from their high initial cost, is that they are subject to injuries, cuts and damage, generally of such a nature that they cannot be repaired except at the factory where they were made or, in a few cities, at a factory branch; often they are damaged beyond repair. This is not only expensive but frequently necessitates the purchase of more than one set of spare tires should the first set be injured while the others are being repaired. A tire of 7-inch section or larger, if run flat, is likely to be ruined beyond repair. In more than a dozen cities operators have said that the principal cost of punctures or blowouts is caused by the necessity of laying up trucks awaiting new tires due to stock shortage, or on account of sending the damaged tires to the nearest factory branch for repair. While repair-mold equipment has been ordered for large-section tires, the heavy demand on the part of the tire factories for new molds of all sizes and the difficulty of producing them has made deliveries very slow.

In nearly every city the large tubes can be repaired locally, but the casings have to be shipped away, the truck operator paying either freight or express charges in both directions. Moreover, it is frequently reported that repaired casings deliver but small mileage due to the over-cure of the joined portions. This danger is more difficult to overcome in large-section tires, due to the longer cure required to vulcanize the interior portions of the new part of the casing. No doubt this feature will ultimately be corrected. The tread seems to give less trouble than the side walls, which are more susceptible to rut wear and overloading abuse.

Because so few service stations are as yet equipped to handle repairs on heavy-duty tires, dependable cost figures are not at present available. In fact, where stocks are available "adjustment" exchanges have usually been made instead of repairs. Of all the causes of dissatisfaction reported for changing back to solid after using pneumatic tires, the most numerous have been those brought about by the delays and expense incident to their repair, including additional spare-tire cost and truck hire while waiting for the return of the damaged tires. Such disadvantages are inevitable in a new development such as the one under discussion but, so far as imperfect service features are concerned, they are being overcome as rapidly as possible. In the meantime, truck engineers, salesmen and operators should not condemn the movement toward the use of pneumatic tires, for undoubtedly it will be the means of increasing the scope of usefulness of motor transportation.

Having thus reviewed the advantages claimed for pneumatic tires on trucks in the debatable field and having specified some of their relative disadvantages, I can say that, in my judgment, the question is too new to be decided theoretically or from such meagre records as are now available.

SPECIFIC CONSIDERATIONS

What general conclusions will guide the operator in the selection of the most satisfactory and economical equipment for his particular installation? So far as I know none has been formulated and given publicity. In this connection, however, I suggest that, in the present state of development, the field for each type of tire may be separated into three classifications, within one of which the operator can reasonably locate his requirements and decide upon his equipment. These three groups are

(1) The imperative field
(2) The economic field
(3) The optional field

The factors that would bring a truck within the first classification for solid tires are: (*a*) If it travels over pavements not necessarily good, but having a reasonably hard road surface to provide traction; (*b*) if the delivery must positively reach its destination without fail, at a promised time; (*c*) if the delivery must be made regularly on a given schedule in which the regularity is a more important factor than either speed or cost of delivery; and (*d*) if it carries heavy loads with frequent overloads beyond the rated capacity of the tires.

Similarly the factors that would bring a truck within the imperative field for pneumatic tires are some combination of the following: (*a*) If it travels over surfaces on which traction cannot be obtained by solid tires, and when the need for traction is such as to outweigh the item of cost; (*b*) if the need for speed of delivery is more important than its cost; and (*c*) if the merchandise carried is so perishable or fragile that it must be protected from road shocks, even at high cost.

The factors that would bring a truck within the economic field for solid tires are (*a*) Short hauls in cities where speed is relatively unimportant, (*b*) heavy loads with a tendency to-

overload, (c) traffic congestion which reduces average speed, (d) loading and unloading delays and (e) need for low delivery cost.

Similarly the factors that would bring a truck within the economic field for pneumatic tires are (a) Road conditions which will not prematurely destroy the tires, (b) long hauls, (c) high average speed, (d) relatively light loads with no overloads, (e) good tire-service conditions and (f) low cost subordinated to quick service.

In analyzing the economic field, the operator must first decide whether or not he can avail himself of the potential speed pneumatic tires would give. This, of course, includes possible delays due to tire trouble as a result of bad road conditions and provided the local tire-service conditions cannot be depended upon. Next, the features of his service provided by pneumatic tires must justify their extra cost.

The distinction between the economic and the optional fields is difficult to make. In fact, the decision as to which is the better equipment may be purely a matter of personal opinion, without strong factors on either side. Hence I shall not attempt to define them.

One of the most interesting and significant developments which I have noticed is the growing tendency among truck operators to use pneumatic tires on front wheels where the need for protection from vibration is the greatest and solid tires on the rear to carry the burden of the load. This practice has much to commend it and should steadily grow in favor. Another tendency is toward the use of some type of cushion or non-rigid wheel which, although equipped with solid tihes, provides extra resilience through its peculiar construction. There seems to be a very large field in which such wheels can be used both economically and advantageously from the standpoint of improved service.

Designing engineers should study to develop cushioning effects that may be possible through other means than tires, such as cushion wheels, improved springs, shock absorbers and the like. While no mechanical device is so resilient as air, much progress must be made before the difficulties are overcome of making air serve acceptably in puncture and foolproof rubber tires, although the industry is making notable improvement in this direction. Finally, all truck operators should keep account of costs, so that intelligent comparisons may be made. In my judgment, the easiest and most effective way to do this so that all records may be readily comparable, is to use the National Standard Truck-Cost System. Thus, if they select tire equipment after a careful analysis of the peculiar conditions surrounding their problems and keep careful and accurate records of operating costs, they can reasonably expect to eliminate many of the annoying uncertainties of their delivery systems and place their tire installations upon a really scientific basis.

AIRSHIPS FOR SLOW-SPEED HEAVY TRANSPORT

WING-COMMANDER T. R. CAVE-BROWNE-CAVE, C.B.E., R.A.F., in the course of a paper read to the British Association at Cardiff on August 27 said:

In considering the applications of aircraft one usually thinks of the high-speed transport of light loads and has an instinctive fear that the load carried may really be too small to be useful. One never thinks of an aircraft as a low-speed weight-lifter, but on investigation it will be found that the airship in suitable form has considerable possibilities in that way. The actual lifting capacity of an airship, exclusive of propelling machinery, fuel, crew, etc., is shown for various sizes in the accompanying table. If it is proposed to use an airship for comparatively short distances and only at times when the wind speed is low and high speed of the ship is not required, the available lifting capacity then becomes large, even for a comparatively small and easily handled ship.

In most parts of the world, and especially at selected seasons, there is a large proportion of time in which the wind speed is not more than 20 miles per hour. In many places the variation of the wind during the day is quite regular and operations may be planned so that the wind is favorable on both out and return journeys. Under these conditions a ship capable of, say, only 35 miles per hour would prove quite a valuable form of transport, although so low a speed would be useless for a passenger trip that must run to time-table whatever the wind, or for a service ship that must work in all weathers.

The table shows the dimensions of the various types of ship that have actually been built and the loads they would carry at an air speed of 35 miles per hour.

These same ships when used as dumb barges having no machinery and fuel would carry the loads shown in column 7.

No actual data exists for the reduction of speed by towing another ship, as the resistance of the towing wire is somewhat unknown, but theoretically an airship capable of 35 knots alone would have, when towing one barge similar to herself, a speed of 28 knots, and with two brages 24 knots.

This operation of towing one airship by another was actually carried out at Barnborough before the war when one small airship, having broken down, was towed home by another. The towing airship A landed close to the damaged one B and 600 feet of wire was attached to A and to B. Both ships were made light and A was released first. She gradually rose into the air, and as the wire grew taut B was similarly released. A then went ahead and towed B home to Farnborough without any difficulty whatever. There was an officer in B to steer and adjust pressure, but no difficulty in control was experienced.

Table I

Type	Capacity	Length	Beam	Gross lift	Useful load: As airship with crew & machinery but no fuel	Useful load: As dumb-barge	H.P. for 35 m.p.h.	Weight of fuel per hour at 35 m.p.h.
	Mil. cu. ft.	ft.	ft.	tons	tons	tons	h.p.	lbs.
					Correct to about 10 per cent.			
Non-Rigid—								
S.S.Z.	·07	143	40	2·1	·73	1·3	26	15·5
C	·2	210	50	6·1	1·4	2·5	120	72·0
N.S.	·4	262	54	12·1	6·4	7·8	170	102
Semi-Rigid—								
A	·6	320	64	19	12·8	14·5	200	120
PL.26	1·09	520	65	33·5	23·5	27	500	300
T.34	1·2	410	70	36	25	28·5	550	330
Rigid—								
R.33	2·0	640	80	60	35·1	38	430	264
L.71	2·4	740	85	73	48·1	52	500	300

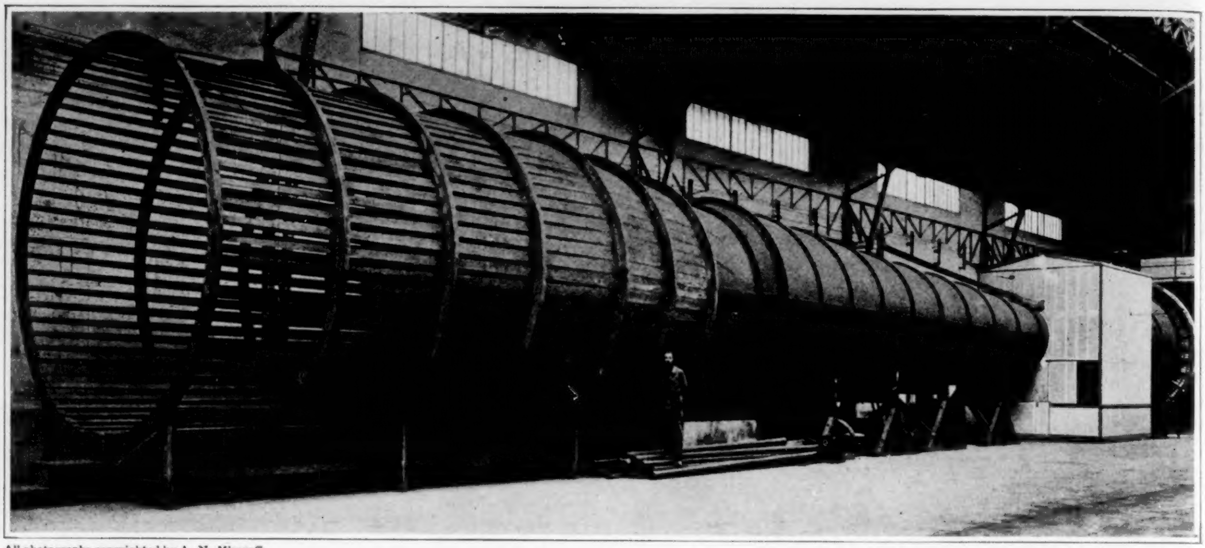
The landing was equally simple. On reaching the landing ground the wire was dropped by A and secured by a landing party who hauled down B. The airship A then landed as soon as the landing party was ready to receive her.

One of the greatest difficulties in carrying out a thorough prospecting survey for, say, oil in new country, is the transport of the machinery to the points proposed. The machinery required for this purpose can certainly be broken up into sufficiently small units to be easily transported by airships and "barges."—Reprinted from *Aeronautics* (London).

AIRPLANE FISH-PATROLS

THE success of airplanes in locating submarines during the war suggested the possibility of using winged patrols to locate schools of fish and reporting these finds to fishermen. This suggestion has been carried out with marked success. A note in a recent issue of the *Aerial Age Weekly* states that as a result of patrols maintained by naval seaplanes, Chesapeake Bay fishermen are making the biggest hauls on record. Reports recently to the Navy Department from the commandant of the naval air station at Hampton Roads said the patrols had proved "indispensable" to the fishing industry of those waters.

Immense schools of fish are spotted almost daily by the seaplanes, it was reported, and fishing fleets are given the location by radio communication or, if within sight, by flag signals.



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THE GREAT WIND TUNNEL OF THE AEROTECHNICAL INSTITUTE OF ST. CYR VIEWED FROM THE EXHAUST END

The Aerotechnical Institute of St. Cyr

New Apparatus for Testing Mechanical Conditions Governing the Flight of Airplanes

THE well-known Aerotechnical Institute connected with the University of Paris and situated near Versailles on the plateau of St. Cyr, whose foundation was due in part to the liberality of the well-known patron of aircraft, M. Deutch de la Meurthe, is at present engaged in conducting some very interesting experiments with respect both to airplanes and to airmen. There have been recently installed for this purpose some new apparatus which permit a precise termination of the mechanical conditions governing the flight of aeroplanes and the instruction of pilots to meet the difficulties which they are liable to encounter in flying at high altitudes.

To begin with there is a *wind tunnel* of truly majestic proportions no less than twenty meters in length and two meters in breadth at the mouth in which various models of airplanes and of dirigibles are tried out. A powerful suction fan provides the necessary current of air.

In order to secure conditions as nearly as possible identical with those found in the open air the air current must have a section sufficiently large to prevent the lines of flow at the periphery of the stream from being affected by the presence of the model.

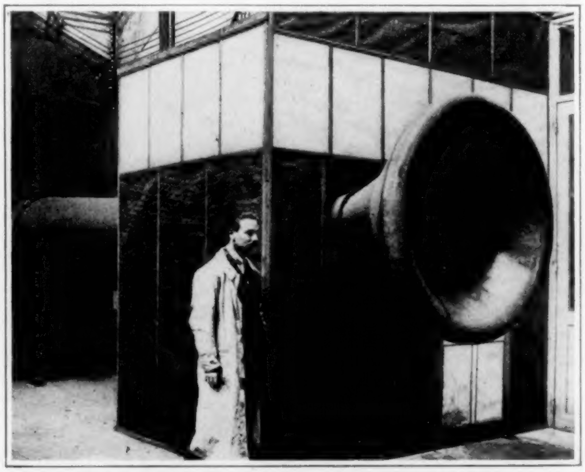
AERODYNAMIC BALANCE

The pressure to which the model is subjected by the artificial current of wind is transmitted to an *aerodynamic balance*. This is installed in a chamber located at about the middle of the wind tunnel. This instrument makes it possible to determine not only the horizontal and vertical components of pressure, but also the center of pressure, a point which it is highly important for airplane builders to have cognizance of. A rod connected with aerodynamic balance transmits to the latter the thrust to which the airplane is subjected, and the operators establish the equilibrium by means of sliding weights. The weight is found first when the model is in calm air and then when it is under the influence of a horizontal air current of known velocity. The difference represents the lift. Special precautions are taken to maintain a uniform velocity of the air stream throughout the duration of the experiment. A special point is made of removing the wall of the cylinder for a certain length and replacing it by a large chamber which is hermetically sealed. In this chamber are placed the aircraft to be tested and the aerodynamic instruments.

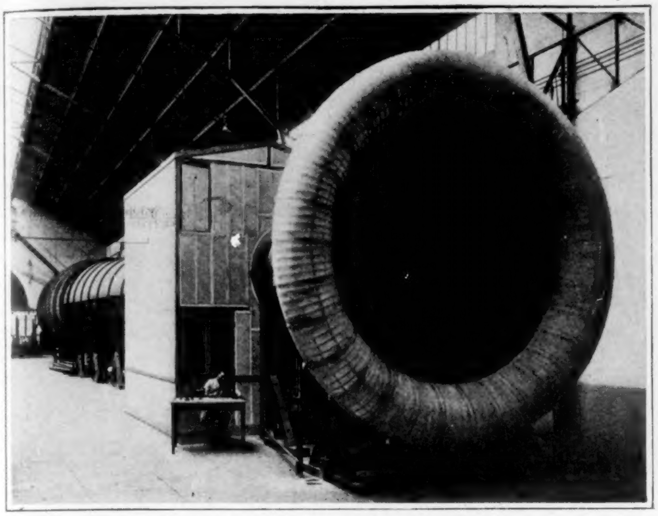
The models are located on the suction rather than the blowing side of the fan because the stream issuing from a fan is so turbulent that it cannot be flattened out sufficiently to secure a constant and uniform flow at all points of the section.

The current of air enters the experimental chamber through a cellular grating which is designed to ensure a parallel direction of the air stream. At the opposite side is the conduit which leads to the suction fan. This contains two gratings of iron wire of 1 cm. mesh; these are separated by a distance of 1.20 m. and they succeed in flattening out almost completely the irregularities of the air current.

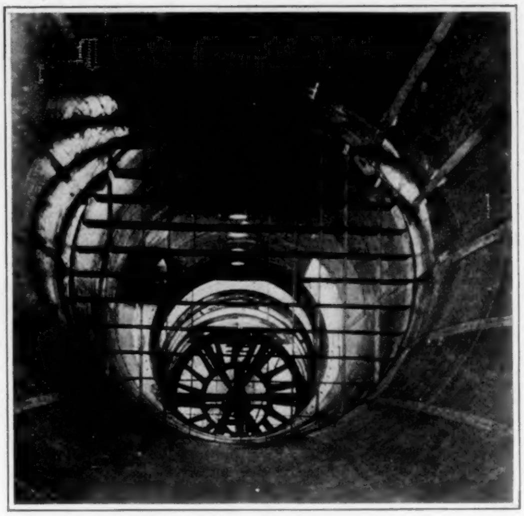
From the fan the air flows out into an enlarged cylindrical extension formed of wooden slats. This permits the air stream to expand progressively and assists in stabilizing the flow. Thus the air stream possesses a uniform direction and velocity throughout the entire extent of the tunnel proper. Furthermore, since it is enclosed in a large hangar the outside wind is not able to influence it. Measurements of the velocities are made by means of a manometer.



MOUTH OF SMALL TUNNEL 0.4M. IN DIAMETER



MOUTH OF THE LARGE WIND TUNNEL
Note the operator seated at the table in front of the experimental chamber and reading the wind velocity on a micromanometer

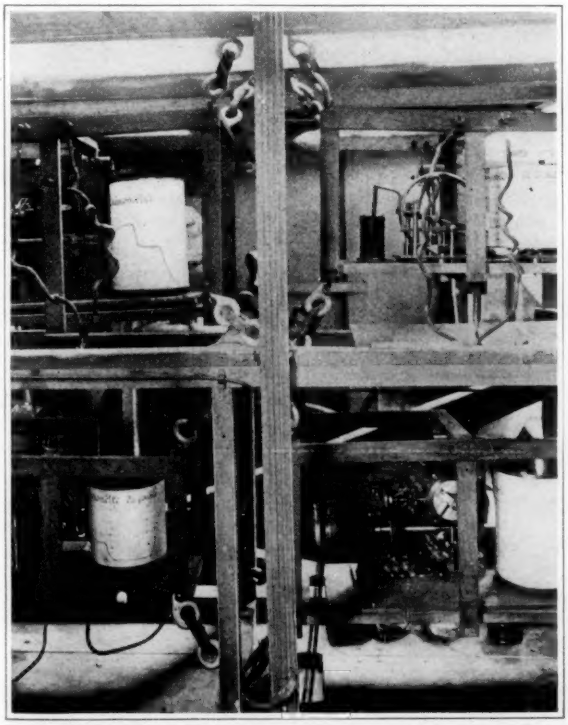


LOOKING INTO THE WIND TUNNEL
Note the fan in the background against which a model under test is indistinctly silhouetted.

For the purpose of testing propellers trucks are provided which run on a track a few hundred meters long. The trucks carry recording instruments and serve not only for determining the efficiency of propellers but also of planes mounted on them.

THE PNEUMATIC CAISSON

To test the aptness of pilots for the proposed work as well as their powers of resistance, they are enclosed in a pneumatic caisson. This apparatus which has been newly installed at St. Cyr makes it possible to determine the degree of attenuation of the atmosphere which an aviator can support without danger to life. The subject to be examined is placed in the caisson which is then hermetically closed. By means of an air pump the pressure is lowered to any desired degree. For example, it may be lowered to 150 mm. which corresponds to an altitude of 12,000 meters in the air. The subject is provided with two tanks of compressed oxygen which he begins to breathe by means of a special mask at a theoretical altitude of 4,600 meters.



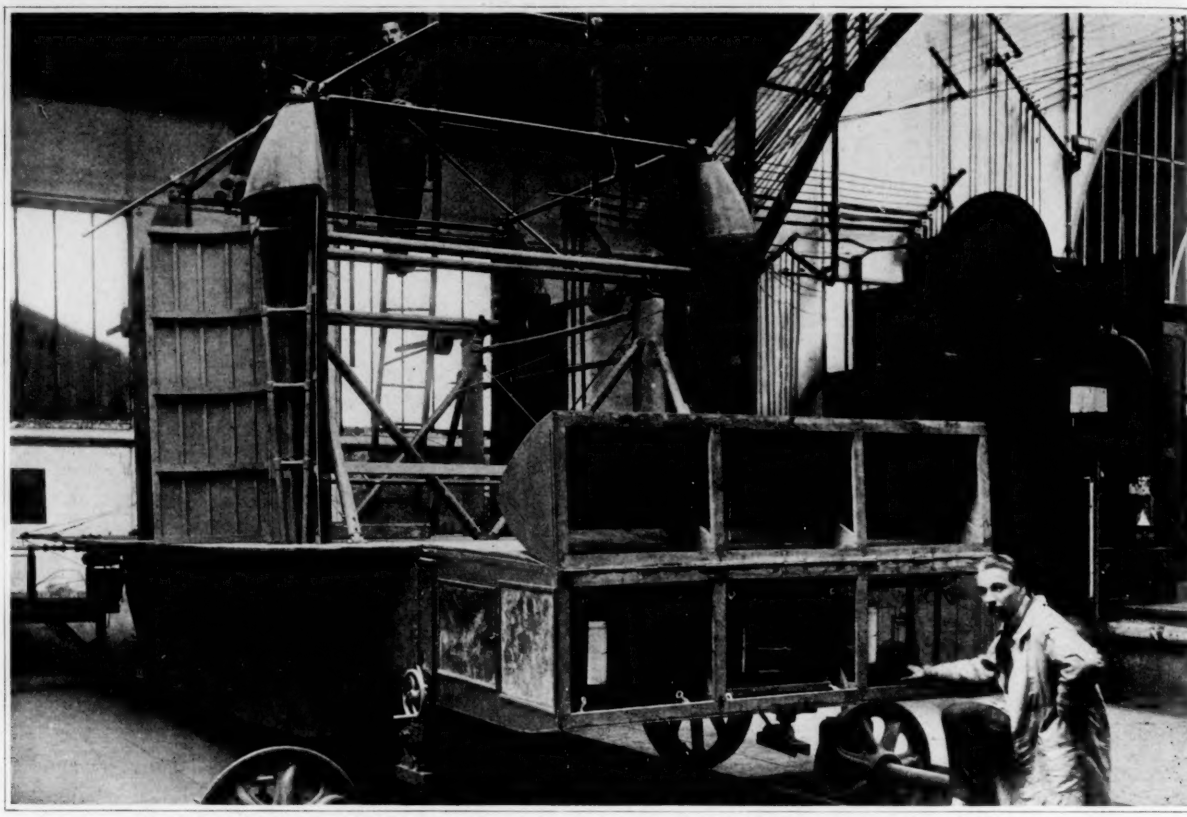
INSTRUMENTS MOUNTED ON THE PROPELLER TESTING TRUCK

It must be remembered, of course, that the maximum altitude to which a man can ascend with safety varies considerably in individual cases. As a usual thing this altitude is scarcely more than 6,000 meters even for men having the greatest power of resistance; but it is a well-known fact that some few "aces" such as Casale have ascended to a height of almost 10,000 meters.

According as the atmosphere becomes rarer, it contains, of course, a lesser amount of oxygen. Hence a person ascending in a balloon or airplane or climbing a mountain is obliged to breathe more rapidly in order to supply his lungs with the amount of oxygen required for the necessary aeration of the blood. If he continues this ascent a moment comes, varying with the individual, when this acceleration in the muscular effort involved in the act of breathing, is no longer able to compensate for the deficit of oxygen in the air. Then, unless an artificial supply of oxygen is provided, serious phenomena of asphyxiation make their appearance. Not only is the blood forced out of its containing vessels at various points, but there are serious internal troubles which quickly cause the death of the aviator unless he is relieved.

It is for this reason that Captain Toussant, the present director of the Aerotechnical Institute of St. Cyr, and Dr. Garsaux, the director of the medical service of aerial navigation, have contrived the pneumatic caisson shown in the accompanying illustrations, whose object is to reproduce the identical conditions to which pilots are subjected when flying at high altitudes. Some of the important physiological work of the latter authority is already well known to the readers of the SCIENTIFIC AMERICAN MONTHLY (see previous articles on "Aerial Diving Suits" in the January issue and "More About High Flying" in the July issue).

As early as 1875 a pneumatic bell jar was constructed by Paul Bert for the purpose of studying the phenomena produced in the human body by the rise and fall of the barometer. In this chamber containing rarefied air, which was built at the Sorbonne, this great physiologist subjected himself to a rarefaction of the atmosphere corresponding to that found at an altitude of 8,000 m., and suffered no inconvenience, thanks to the inhalation of oxygen. But this device while admirable at



TRUCK ON WHICH PLANE SURFACES ARE TESTED AND RECORDING INSTRUMENTS REGULATED

the time is not sufficiently precise to meet the requirements of modern aviation..

In the beginning the installation of St. Cyr which was conceived in September, 1917, had for its sole object the study of respiratory apparatus designed to facilitate the task of military and other aviators. Afterwards the range of study was greatly extended, and various modifications and improvements were made with the idea of securing a rapid decrease of tension in the air combined with the action of cold with, at the same time, a constant renewal of the internal atmosphere. Since that time Dr. Garsaux and his collaborators have pursued numerous studies with regard to the manner in which the human body behaves under conditions of extremely low barometer, of very low temperature, of rapid variations of pressure, etc.

The caisson serves further to make various mechanical tests of the apparatus employed, such for example, as variations in the yield of the gasoline pumps, of aircraft motors, under a falling barometer, measurements of the velocity of combustion, of the *pulverine*, etc.

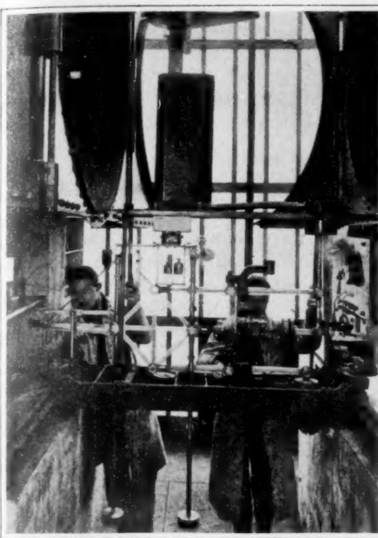
There are now to be seen at the institute two large sheet iron cylinders; the first of these, which is 5 m. long by 3 m. in diameter is now in course of being mounted (August, 1920); the second is 3.60 m. long by 2 m. in diameter. This latter has thus far been employed for the tests and experiments hereafter described. By the side of this is erected the Burckhardt and Weiss suction pump; this pump, which is operated by an electric motor having a velocity of 200 revolutions is capable of exhausting a volume of 5.2 cm. per minute. The pump which is firmly secured to a concrete base, absorbs 6 hp. at its maximum rate of operation; but by means of a rheostat its velocity can be lowered to only 80 revolutions per minute.

The cylindrical wall of the vacuum chamber is composed of sheet iron plates 5 mm. thick riveted together and the end walls of similar plates but of double thickness. The door at one end of the caisson is hung upon hinges whose axes are pivoted in holes of oval shape in order that they may this as soon as the door is closed its air tightness is further a band of rubber surrounding the periphery of the door permits the latter to fit hermetically against the caisson. Besides this as soon as the door is closed its air tightness is further secured by four iron cross pieces bolted on.

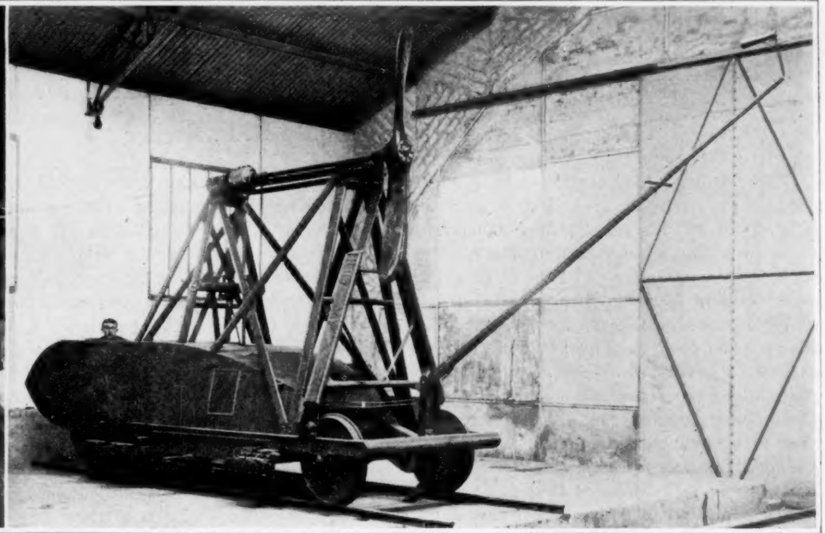
On each side of the pneumatic caisson there are four port holes, each 25 cm. in diameter and arranged at about the height of a man's eye, so as to permit the attendant physiologist to watch the effect upon the patient. There are also two valves regulated by hand-wheels, which admit air into the chamber at any desired rate. One of these is operated from the inside and the other from the outside. Finally, the entire caisson rests horizontally on a wooden framework and a layer of cork with coaltar binder 10 cm. thick entirely envelopes it.

Within this vacuum caisson are placed various instruments and accessory apparatus. These include a recording altimeter and a manometer; furthermore, above the rheostat which controls the pump is placed a signal board comprising a series of electric lamps of different colors whose illumination is controlled from within the caisson. A replica of this board is installed inside in order to secure control of the proper functioning of the said signals. Furthermore, there is a telephone with a double bell to render it possible for the subject of the experiment to communicate with the mechanician in charge of the pump.

The apparatus for securing a low degree of temperature comprise a Claude compressor and expander capable of furnishing about 200 cubic meters per hour of air cooled to 97°C. The lowering of the temperature in the caisson is secured by allowing the external air to penetrate into an auxiliary receptacle, for it mingles with cooled air before being drawn into the pneumatic bell jar. There are two tanks of compressed oxygen, each containing 540 liters which communicate directly with the interior of the latter and the experimenter can open these instantly from the outside in case the subject



AERODYNAMIC BALANCE IN THE TUNNEL



THE TRUCK WHICH TRAVELS ON A TRACK AND ON WHICH THE EFFICIENCY OF PROPELLERS IS TESTED

being tested shows signs of illness. Furthermore, there are various automatic respiratory apparatus at the disposal of the subjects, as well as a tank containing 540 liters of oxygen which can be opened instantly in case of emergency.

In this pneumatic laboratory Dr. Garsaux has performed a great many experiments. He has worked with as many as ten assistants or subjects at a time and in vacua corresponding to altitudes of from 8,000 to 9,000 meters. Quite recently Jean Casale has been able to "ascend" in this theoretical manner to a height of no less than 12,000 m. (39,370 feet). This well-known aviator entered the caisson and the barometric pressure was then brought to a height of 150 mm. of mercury. At a degree of pressure corresponding to 4,600 m. of altitude, he began to breathe oxygen by means of an automatic respiratory mask.

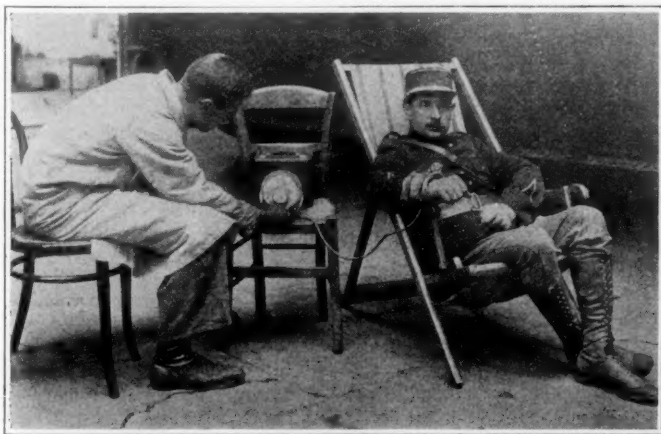
The aviator was observed by Dr. Garsaux and Dr. Mathieu de Fossey; in the course of forty-seven minutes the famous "ace" made an "ascension" without the least discomfort; the pressure was restored gradually during a period of twenty minutes, at the end of which he emerged from his prison feeling almost or quite as fit as when he entered it.

The physiological tests carried out at St. Cyr, make it possible to determine, among other things, the average height at which aviators can remain without physical danger and without losing their bodily abilities. This maximum altitude varies according to the individual, but it exceeds 6,000 m. in exceptional cases only.

Thanks to this pneumatic caisson Dr. Garsaux has also been able to analyze the respiratory exchanges of gases which occur at different altitudes, and to determine in consequence the altitude at which the inhalation of oxygen becomes advisable, which he finds to be from 3,500 to 4,000 m. For example, the heart action is measured by means of the Pachon oscillometer. In the same way the physical and meteorological problems which are so intimately connected with those involved in aeronautics are experimentally studied.

With the Pachon oscillometer he has measured the arterial tension in the course of ascent and of descent at different altitudes, both with and without oxygen. He has likewise studied the influence of increasing rarefaction upon the duration of the psycho-motor reflexes, the effect of the rarefaction and of the recompression upon the ears and other organs of the body.

All of these experiments have the effect of improving the various automatic respiratory apparatus put in service in the Allied Air Squadrons for flight at high altitudes, shortly before the armistice. These include the automatic oxygen valve and barometric governor, the gas reservoirs and the masks, all of which were described in the Scientific American Monthly for July, pp. 70-73.



TESTING A PILOT'S BLOOD PRESSURE WITH THE PACHON OSCILLOMETER

INTERIOR OF CAISSON IN WHICH PILOTS ARE SUBJECTED TO RARIFIED ATMOSPHERE

The Variable Camber Wing

An Airplane Wing That May Be Adjusted for Variable Speeds

By H. F. Parker

[*The National Advisory Committee for Aeronautics recently published a report on a variable camber wing invented by Mr. H. F. Parker. We reprint here the introductory part of the paper including a description of the rib structure. The Parker rib was thoroughly tested at the U. S. Bureau of Standards and was found to compare favorably in strength with those built up rigidly in the ordinary way. A series of aerodynamic tests were also made on sections of the various forms the wing would assume in passing from one extreme position to the other and the wings were tested as monoplanes and in biplane and triplane combinations. For a full description of these tests and their results we would refer the reader to Report No. 77 of the National Advisory Committee for Aeronautics, Washington, D. C. It should be noted that at the time the wing was designed it was Mr. Parker's belief that the wing would be automatic in operation. Subsequent examination indicates that this is not true at least for the rib as now designed.*—EDITOR.]

THE most important single problem in aeronautics awaiting solution is that of increasing the speed range of airplanes. In recent years maximum speeds have been increased very greatly, and will no doubt be still further increased, but each addition has been accompanied by an increase in the landing speed. The landing speed has always been about half the maximum and could not be reduced below that amount without entailing the expenditure of additional power. This is due primarily to the properties of the type of wing which has been used.

In flying, the method utilized to change the speed is to alter the angle of attack of the planes. This must also be accompanied by an alteration in the power output of the engine if the machine is to be kept flying level. Manipulation of the engine throttle without alteration of the angle of the planes will not cause a change in speed; the machine will ascend or descend at its former speed. The speed is therefore dependent on the angle of attack. If this could be efficiently varied from a very small to a very large angle, a wide range of speeds could be obtained. Two things prevent this: First, the lift does not increase directly with the angle of incidence for all angles. It does so up to about 15° but for greater angles, instead of increasing, the lift actually falls off. This falling off occurs in all types of wings though in some cases it is only slight and in others very considerable. No increase in speed range can be obtained by increasing the angle of incidence beyond 15°. Second, the efficiency of the plane is not maintained at low angles. As the incidence is reduced from the maximum of 15°, both the lift and the drag decrease, the drag at first falling off more rapidly than the lift. At about 3° a point is reached where the ratio of lift to drag is a maximum. This is the most efficient flying angle for the plane. As the incidence is further decreased, the lift continues to fall off rapidly. The drag, however, decreases more slowly, being a minimum at zero incidence. For negative angles it again increases.

This means that the ratio of lift to drag falls off very rapidly, and the wings of a machine flying at a smaller angle of incidence than 3° offer more resistance than they do at that angle. The line from which these angles are measured is the chord of the aerofoil, i. e., the common tangent to the lower surface. This is not necessarily the position in which the wing gives no lift. Most wings give a considerable lift when their chord line is parallel to the direction of the air flow, and this lift only becomes zero when the nose of the wing is about 3° below the trailing edge. In fact, fast machines frequently fly with their planes set at negative angles.

If a maximum speed of double the minimum is to be obtained, the machine must fly under the inefficient conditions existing at these small positive or even small negative angles of incidence. If it is to be more than double, as it must be in order to obtain a reasonable landing speed in machines flying at over 100 miles an hour, the small lift necessary at high speeds is accompanied by a prohibitive drag.

The problem of increasing the speed range may be approached in a number of ways, but confining ourselves to devices applicable to the present type of airplane, which eliminates the helicopter and similar machines, there are three ways by which a solution might be achieved. These are:

Variable angle of incidence.

Variable surface.

Variable camber.

Each of these presents great mechanical difficulties, but the first is the easiest of attack and has consequently approached nearer a solution than either of the other two. It offers two advantages: First, the axis of the fuselage can be kept parallel to the path of flight at all speeds, thus securing a minimum drag over the entire speed range. In the present machine, having the wings fixed in relation to the fuselage, the fuselage is at a considerable angle to the flight path over a portion of the speed range. Under these conditions the variable incidence machine is more efficient than the present type. Over that portion of the speed range where the fuselage of the standard machine lies along the flight path, or only a few degrees from it, the variable incidence machine offers little or no advantage. Second, the wings of the variable incidence machine can be tilted to a much greater angle than is possible in the present machine. This permits the machine to be brought to rest more rapidly. It does not, however, reduce its minimum flying speed. Thus the advantages of variable incidence, though well worth attainment, do not provide a sufficiently complete solution of the problem.

The next for consideration is variable surface. Theoretically, this gives a perfect solution. If the wings of the airplane could be increased in area during flight, the speed could be reduced so as to land as slowly as desired. Conversely, given sufficient surface to insure a low enough landing speed, if the surface could be reduced in flight the planes could always be made to operate at the angle of incidence giving the best lift/drag ratio, thus securing the least possible drag at maximum speeds. Unfortunately, mechanical difficulties prevent the realization of this method. These difficulties are so serious that there does not seem any prospect of their being overcome in the near future.

Finally, there is a variable camber. This offers advantages very much greater than variable incidence, but is more difficult of solution mechanically. On the other hand, as compared with variable surface, it is mechanically possible, but its aerodynamic advantages are not quite so great. Yet they are, however, great enough to provide a satisfactory solution of the problem and the only one, apparently, which is practicable.

So much for the accepted methods of increasing speed range. The method under discussion in this paper cannot be properly classified under any of these headings. In conception, however, it is derived from variable surface, though the mechanical device utilized is distinctly variable camber.

Let us return to the conception of variable surface. A machine so equipped would have a comparatively small amount of fixed surface, together with a larger amount of removable surface. While landing, both fixed and removable surface would be in operation, but at high speeds the fixed surface alone would support the machine. Assuming that a mechanical device to operate such a system is possible, it is obvious

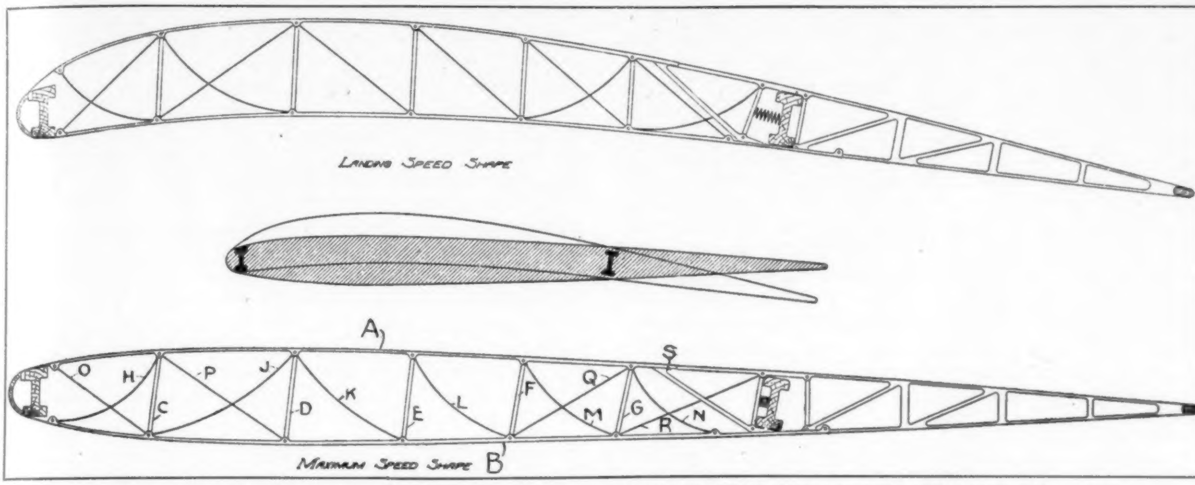


FIG. 1. CONSTRUCTIONAL DETAILS OF THE VARIABLE CAMBER WING AND ITS TWO EXTREME POSITIONS

that the mechanism would entail a considerable increase in weight, and probably also in head resistance. This may be expressed in terms of the resistance of the wings that have been removed. For example, 100 units of drag may have been eliminated by removing a portion of the wings, but the equivalent of 20 added by the extra weight and increased resistance. This, then, would leave us a net saving of 80 units.

Suppose, now, that instead of removing the wings we leave them in place, but when they are not required for lifting we change them to a shape offering only a fraction of their former drag. If this fraction is approximately the same as that required for variable surface we will have all the advantages of variable surface, and the problem will become one of changing the wing from an efficient lifting shape to a shape offering the least possible resistance; for example, pure stream line. Experimental results show that such a saving can be effected; the drag can be reduced from 100 units to 25, giving us a net saving of 75 units. In a biplane the upper plane will be of fixed construction and the lower one variable, or vice versa; while in a triplane a suitable arrangement is obtained by using a fixed wing for the center plane and placing variable wings above and below it. At high speeds the variable planes are to carry no load and are to be stream line in shape. At low speeds they are to bear their share of the weight of the machine and are to be deeply cambered. For a stream-line wing to give no lift it must lie parallel to the direction of the air flow, and then the forces on its upper and lower surfaces are equal. It is necessary, therefore, to set the stream-line planes at zero angle of attack when the fixed planes are at their angle of maximum lift/drag, usually about 3°.

For slower speeds the angle of attack of the fixed plane must be increased, let us say, from 3° to 9°, a change in angle of 6°. The stream-line plane is carried through the same angle and now has unbalanced forces acting on it, tending to deform it upward. These forces are the greatest near the leading edge, and decrease rapidly as the trailing edge is approached. If we place one wing spar at the leading edge and another about two-thirds of the chord back from it, we divide the wing into two parts, with the force on the front part very much greater than that on the rear part. If, now, we make the part between the spars of flexible construction and the part behind the rear spar rigid, and allow the ribs to slide over the rear spar, we provide for a change of shape under load. The portion between the spars is carried upward, while the rear portion, being rigid and fixed to it, moves downward. The result is a cambered wing.

The rib should be just rigid enough to deform a certain desired amount under the maximum load it should carry normally, and the deformation should be proportional to the load upon the rib up to full load. The load at any time will depend on the ratio of the lift coefficient of the variable plane at its angle of attack to the lift coefficient of the fixed plane at its angle. Thus, at maximum speed when the variable plane is stream line in shape the proportion is zero to the lift coefficient of the fixed plane, and the load is zero. At landing speed the lift coefficients of the two planes are approximately

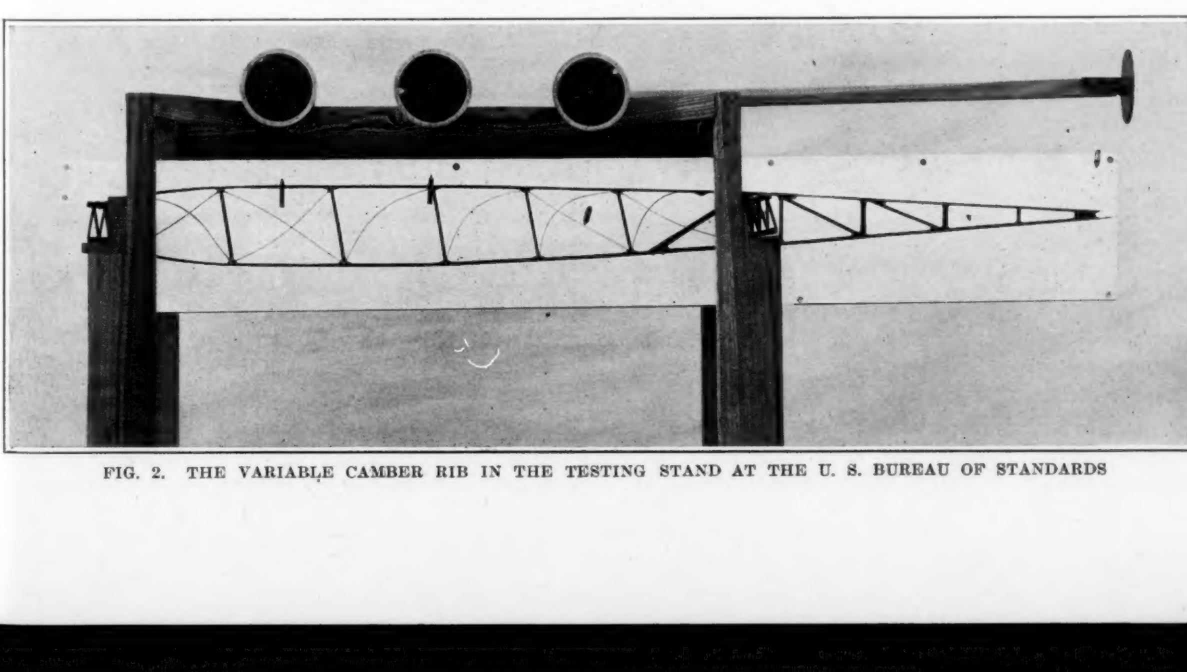


FIG. 2. THE VARIABLE CAMBER RIB IN THE TESTING STAND AT THE U. S. BUREAU OF STANDARDS

equal—the variable plane is carrying half the load and its load and deflection are a maximum. In an intermediate case, when the planes are at 6° and 9°, respectively, the lift coefficients are, let us say 1 : 3. The variable plane is now carrying a quarter of the load, or one-half its maximum load, and its shape will be half-way between the extremes. It is now a lifting aerofoil, but a lightly cambered one. As lightly cambered aerofoils are most efficient at small angles, and heavily cambered ones at large angles, the variable wing possesses the most suitable shape throughout its range.

If the decalage remained unchanged, i. e., if the setting of the variable plane relative to the fixed plane remained the same for all angles of attack, when the fixed plane was at its angle of maximum lift the variable plane would be 3° short of it, and would not be operating under the best conditions. This is not the case, however. In changing the shape of the wing the trailing edge was depressed and the angle of attack in consequence was increased. This change in decalage is dependent on the position of the rear spar and on the amount of maximum camber. In the aerofoil used it is 3°, so that when the maximum lifting effort is required both fixed and variable planes are operating most efficiently.

It is obvious that under certain conditions—gusts, for example, or flattening out after a steep dive—the wing will be subject to a load greater than its normal maximum. This would be liable to cause further deflection, which would be undesirable. The wing under discussion ceases to deflect after the application of its normal maximum load. This is accomplished by means of an internal bracing system which only comes into operation when the maximum deflection has been reached.

In designing a wing possessing these variable camber features the following considerations had to be kept in mind:

It had to deform regularly with the load up to unit flying load, then remain rigid under further applications of load, and be strong enough to bear several times its normal load without failure. It had also to be capable of easy manufacture, to be simple and foolproof in operation, and light in weight. Metal construction was practically a necessity, and to avoid new features which might be doubtful engineering practice, standard construction was adhered to wherever not essential to the functioning of the device. The ribs were thus the only parts of the wing requiring alteration, leaving spars, bracing wires, struts, etc., substantially as at present. Figure 1 shows the general construction adopted. The essential parts are:

1. Channel-shaped strips *A*, *B*, forming the upper and lower surfaces of the rib between the spars.

2. Compression links at *C*, *D*, *E*, *F*, and *G*. These are also of channel section and are fixed to the outer channels by pins, allowing the necessary angular motion between links and strips.

3. Tension links *H*, *J*, *K*, *L*, *M*, and *N*. These are flat strips of steel attached to the same pins which carry the compression links. In the stream-line position they carry no load and bow as shown, but in the lifting position they straighten out and make a truss of the rib, preventing further deformation under overloads. The links in the first two and last two panels are slotted to allow the insertion of reverse links.

4. Reverse tension links *O*, *P*. *Q*. and *R*. The only function of these is to prevent the rib from being deformed beyond its stream-line position when subject to loads on the upper surface.

5. A tailpiece, fixed in shape, riveted to the upper strip at *S* and constructed to slide over the rear spar.

6. A spring placed between the rear spar and the tailpiece. Provided the channels *A* and *B* are made of sufficient size, a rib can be made which will function properly without this spring, but its use effects a considerable saving in weight.

The upper and lower surfaces are fixed to the front spar, which is placed practically at the leading edge. A light wooden nose piece running the length of the wing and attached

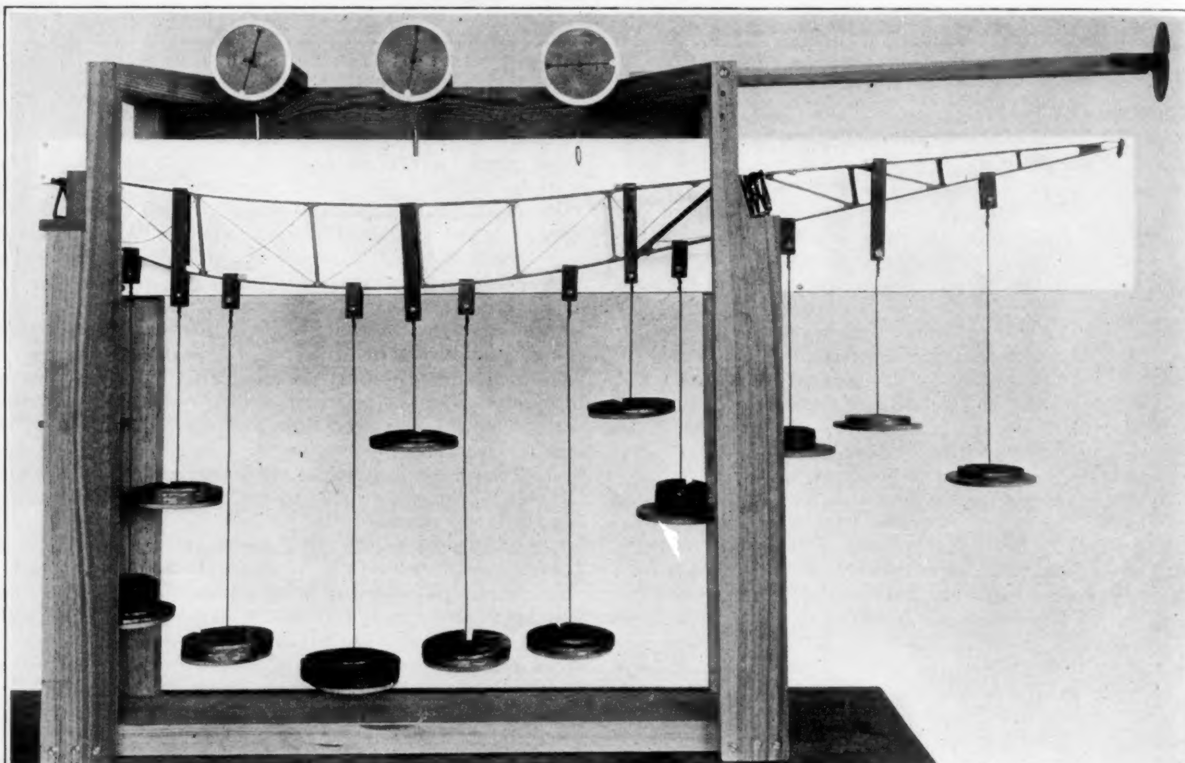


FIG. 3. THE INVERTED RIB BEING SUBJECTED TO A LOAD TEST

When subjected to six times the flying load a maximum permanent set of 5/32 inch occurred in the first and second panels. When loaded to destruction failure occurred at eleven times the flying load.

to the spar gives a fair shape to the leading edge. The rigidity of the rib, due to the stiffness of the channels and the spring, must be such that it attains its full lifting form under normal flying load. The lengths of the tension links determine the final contour of the wing.

The fabric is continuous over the wings except where the lower flexible channel is connected to the tailpiece. Here it is discontinuous to permit the sliding forward of the fixed tail portion over the end of the channel forming the flexible portion of the lower surface. The amount of this sliding motion is approximately 1 inch, and it may be provided for either by allowing the surface to overlap or simply by leaving a gap of this amount. In the former case the surfaces would just meet when in the stream-line position and would overlap 1 inch in the lifting position. In the latter case they would meet when in the lifting position but in the stream-line position would leave open a strip 1 inch wide running the length of the wing. It is not believed that this would be as objectionable as might appear at first sight, for the aerodynamic properties of the wing would not be appreciably affected. It will probably be preferable to stitch the fabric to each surface separately, though there is no objection to the stitching going over the top and under the bottom, except at the rear spar, as the distances between the surfaces do not alter. It was necessary to determine whether any excessive stretch in the fabric would be caused by the functioning of the ribs. The lower surface changes from a convex to a concave shape of approximately equal curvature. There will, therefore, be no stretch in the fabric. In the upper surface, however, where an increase of convex curvature occurs, there will be a stretch caused in the fabric. Calculation shows that this is not serious. In a wing of 60-inch chord, with a maximum increase of camber of 2½ inches, the maximum stretch of the fabric is only 1/100 inch in the 15 inches in which the greatest change occurs, or 0.067 per cent. As the stretch at rupture is 15 per cent, the fabric is only strained 1/225 of this amount.

NICKEL-PLATING ALUMINUM AND ALLOYS

It was long considered practically impossible to produce a durable plating of nickel upon aluminum and its alloys, particularly because of the lack of adhesion between the two metals. In 1914, however, the French *Revue de Metallurgy* (Paris) published a note by M. Tassilly proposing a method of accomplishing this by means of previously attacking the metal with hydrochloric acid, but while this received a certain amount of industrial application a careful study of the process showed great irregularity in its application to the various light alloys of aluminum, by reason of the non-uniform action of the cleansing agent employed. The problem has recently been freshly studied by MM. Leon Guillet and Maxime Gasnier, and results of their investigation were presented to the French Academy on April 25, 1920.

Finding by a microscopic examination of various nickel-plated articles that the adhesion of the deposit of nickel was due merely to the fact that metal catches in and clings to the minute cavity produced by the scouring agent, these investigators conceived the idea of accomplishing the necessary scouring by means of a sand blast.

Four factors were found to enter into the operation:

A. The velocity of the grains of sand projected upon the surface of the metal;

B. The size of the grains of sand;

C. The time elapsing between the application of the sand blast and the process of nickeling;

D. The thickness of the layer of nickel deposited.

The bath employed in the process of the nickel-plating in all these tests was that ordinarily used in industry, consisting of the sulphate of nickel (150 grams); the double sulphate of nickel and ammonium (50 grams); and sufficient water to make one liter of solution.

In order to find the character of the deposit the adhesion was tested first by hammering with a ball, in which case the sheet of aluminum was 6 mm. thick, the ball 10 mm. in diameter and the indentation 6 mm.; secondly by bending tests, the sheet of metal in this case resting upon two supports 55 mm. apart and being bent by means of a punch with a semi-cylindrical nose 25 mm. in diameter; and finally, by burnishing tests, a steel burnisher being used with a solution of soap as a lubricant. The efficacy of the protection afforded by the layer of nickel was tested by immersing the nickel-plated articles in boiling soda lye, containing 15 per cent of NaOH for a period of thirty minutes.

1. When the sand ordinarily employed in the sand blast, i.e., Fontainebleau sand, yielding 30 per cent of refuse in a screen of 0.3 mm. mesh and 10 per cent refuse in a screen of 0.2 mm. mesh, and with a deposit of nickel 0.01 mm. in thickness, the experimenters obtained the following results:

Pressure per square centimeter	Hammering tests
300 grams	Nickel completely exfoliated
600 "	" slightly crocked
1,500 "	" intact

But the grain of this deposit was rather coarse and it was found that this defect can be avoided by making use of a finer grain of sand, i.e., sand which passes through a 0.2 mm. mesh.

2. It was found that sheet metal treated with the fine grained sand and under pressure of 1,500 grams per square centimeter could be kept in good state if wrapped in a sheet of filter paper, for as much as 2, 8, 15, or even 30 days before being nickel-plated.

3. Sheets of metal treated with the sand blast under these conditions have been nickel plated with layers of increasing thickness up to 0.04 mm.

The mechanical tests described above showed that the deposit is of excellent character up to 0.01 mm.; when the deposit is 0.02 mm. thick a certain amount of scale is exhibited; the adhesion is insufficient where the deposit is 0.04 mm. thick. However, it is only this latter thickness which affords an effective protection against the action of the soda lye.

4. It is obvious that if a high resistance from a chemical point of view could be imparted to aluminum and its alloys, many new applications might be found for them. Consequently the present investigators sought another plating method.

One of them had previously demonstrated that copper yields by electrolysis a deposit much more compact than that of nickel and not so hard (Guillet et Bernard: *Bulletin de la Societe d'Encouragement pour l'Industrie Nationale*, 1914). This fact suggested the idea of employing two layers of nickel separated by a layer of copper, since the direct copper plating of aluminum does not give satisfactory results. The following method was finally worked out:

(*a*) The metal was treated with a sand blast under a pressure of 1,500 grams per square centimeter, the sand being fine enough to pass through a screen of 0.2 mm. mesh. (*b*) A coating of nickel 0.006 mm. thick was applied, the length of the operation being half an hour at 0.8 ampere per square decimeter. (*c*) A layer of copper was next applied 0.02 mm. thick, the length of the operation being two hours at one ampere per square decimeter; the copper bath employed containing 150 grams of copper sulphate, 20 grams of sulphuric acid and sufficient water to make one liter. (*d*) The layer of copper was then polished. (*e*) A second plating of nickel 0.005 mm. was next applied, the operation lasting one hour at 0.5 ampere per square decimeter. (*f*) The surface of the nickel was polished.

These conditions satisfactorily met a portion of the mechanical tests: namely, the hammering produced no scaling; bending was accomplished up to an angle of 120° and the process of burnishing produced no alteration; it also successfully met the chemical tests, resisting a 15 per cent solution of soda lye at a temperature of 100°C.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

The National Research Council is a coöperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

SCIENTIFIC SURVEY OF THE PACIFIC

Formulated by the First Pan-Pacific Scientific Congress, Honolulu, Aug. 2-20, 1920

By Clark Wissler,

Chairman of the Division of Anthropology and Psychology of the National Research Council and Curator for Anthropology, American Museum of Natural History

It may be a surprise to many to learn that the Pacific Ocean is still sadly in need of thorough-going exploration. When one takes up a well-prepared atlas or an expensive globe, the impression is given that everything has been definitely determined, that the islands are all set down in their correct places, that the reefs and depths of the ocean are marked, etc. Lines upon a map are always definite enough in themselves, but, for all that, they may fall far short of giving a true picture of the earth's surface. The facts are that in our maps of the Pacific Ocean many tiny islands are wrongly placed, some are omitted entirely, while some are found only on the maps, and so are comparable to the long lost land of *Atlantis*. Hundreds of dangerous coral reefs in the South Pacific are not to be found upon the navigator's charts and undoubtedly several ships are lost each year from the lack of such data. The commerce of the Pacific follows a few narrow lanes, within which the danger spots are known, but when a vessel is so unfortunate as to be driven far out of its course her officers often feel their way along with fear and trembling. But lamentably deficient as is our knowledge of the geography of the Pacific, it is far more extensive than our knowledge of this area in many other ways. Very little is known of plants and minute animal life in many of the islands and even less is known concerning the fishes and marine fauna. Parts of New Guinea and of the neighboring islands are absolutely unexplored. Finally, there are primitive peoples in many of the islands and even in the remoter parts of Australia who have never seen white men. In short, the world today is woefully ignorant of its largest and most magnificent ocean.

ORGANIZATION OF THE CONGRESS

To take immediate steps toward the correction of this deficiency a three weeks' conference was held in Honolulu last August. This was a gathering of representative scientific men from the countries in and around the Pacific Ocean. The conception of such a conference originated with Alexander Hume Ford of Honolulu, the Executive Secretary of the Pan-Pacific Union, and the initial steps were taken by the Governor of the territory of Hawaii. Upon the recommendation of the Governor of Hawaii, the Government of the United States authorized the conference and appropriated a small sum of money to meet the initial expense of it. The preliminary organization of this conference as the First Pan-Pacific Scientific Congress was delegated to the National Research Council of the United States. Sixty scientists assembled in Honolulu by invitation, men who were recognized masters in their respective fields, many of them specialists in problems pertaining to the Pacific. The countries represented were Japan, England, Australia, New Zealand, Canada, the United States, the Philippine Islands, and the Territory of Hawaii.

Prof. Herbert E. Gregory of Yale University was elected president of the Congress and Dr. A. L. Dean, president of the University of Hawaii, secretary.

Chairmen of the respective sections of the Congress were: *Anthropology*, Clark Wissler, curator of anthropology, American Museum of Natural History, New York City.

Biology, Charles Chilton, professor of biology, Canterbury College, Christchurch, New Zealand.

Botany, W. E. Safford, economic botanist, United States Department of Agriculture.

Entomology, F. Muir, entomologist, Hawaiian Sugar Planters' Association.

Geography, William Bowie, chief, Division of Geodesy, United States Coast and Geodetic Survey.

Geology, T. Wayland Vaughan, United States Geological Survey.

Seismology and Volcanology, Fusakichi Omori, director, Seismological Institute, Tokio, Japan.

The keynote of the Congress was coördination of effort in exploration and research. This should result in the correlation of all the available data upon the scientific problems of the Pacific area. The men who come together, though representing many distinct scientific fields, were unanimous in the opinion that advance in our knowledge of the Pacific area would be expedited when, and only when, the narrow but effective special methods of the several fields of research were systematically brought to bear upon the same problems.

Some of the most fundamental scientific problems of this area relate, for instance, to food supply, the production and preparation of food, involving a great complex of nutritive and cultural elements,—natural, social, and psychological. Long before white men sailed into the Pacific, other peoples had made discoveries there and planted colonies. Where these peoples originated and how they came to the islands of the Pacific are other unsolved problems. The natives occupying the great central island area of the Pacific are called Polynesians. When discovered they possessed many cultivated plants. The origin of these plants is yet another of the problems of the Pacific whence came the original seed, how did the plants reach the different islands, what are the ethnological contacts indicated by the possession of these plants?

It was made clear in the discussions of the Congress that the answers to such questions as are presented in these problems were not to be obtained by the methods of one science alone. Anthropologists who are studying the Polynesians must bring to bear their knowledge of native Polynesian agriculture and of Polynesian migration. The oceanographer also must furnish information upon the ocean as a factor in the distribution of plants. Even the entomologist and plant pathologist must be called upon to contribute data on the minute parasites that infest plants in the different islands, because these may have been carried in with the original stock. It is only from intensive work in all these fields and the weaving together of results that we may expect a solution of any one phase of the complex problem of food supply. This large group of problems thus includes many which in themselves are economic, ethnological, or entomological, but which have important interrelations. Accepting then the principle that no one science is able to proceed entirely alone, this first Pan-Pacific Scientific

Congress set itself the tasks, first, of formulating the scientific problems of the Pacific and, next, of organizing concerted effort for the solution of these problems.

This statement of aims and methods for research in the Pacific area will be an important document. In the first place it will summarize the present state of scientific knowledge for that area under the following heads: anthropology, biology, botany, entomology, geography, geology, seismology, and volcanology. Following each of these sections will be outlines of new researches necessary and specific recommendations for their prosecution. The importance of these statements will lie in that they will constitute a consensus among representative scientific men, and will be, therefore, authoritative.

PROBLEMS RECOMMENDED BY THE CONGRESS

A clearer idea of the work of the Congress may be had from a look at a few of the problems so far outlined. Realizing that among the first essentials to accurate observations in the islands of the Pacific are geological maps, it was resolved that the first thing to do should be the construction of base maps showing the important topographical features. The standard maps of the world are now by international agreement projected on a scale of 1:1,000,000 and it is according to this standard that these much-needed maps of the Pacific area are to be prepared. Much of the necessary data for this work is still to be obtained. In addition, two special series of maps were provided for, one showing the distribution of geological formations and another the distribution of mineral resources. Special recommendations were made for a geological survey of Hawaii, Fiji, and a number of smaller islands, the formations of which are scarcely known.

Another subject to receive attention is the contour of the bottom of the Pacific Ocean. Such knowledge is of practical value in navigation, but is especially important as supplementary to geological interpretations of the shore lines of continents. Little headway can be made with the determination of the framework of the Pacific region and its geological history until the form of the bed of the Pacific is known. To this end many additional soundings must be made before satisfactory charts can be prepared. It is the hope of the Congress that the several nations around the Pacific will take steps to have these soundings made and the results reported. These problems, among many others which might be mentioned, indicate the kind of program now before the geologists of the countries bordering the Pacific Ocean.

Another group of related problems concerns volcanoes and earthquakes. The destruction of life and property from these causes in and around the Pacific area probably exceeds that in any other part of the world. The development of seismology or the detection of earth movements and tremors by means of a seismograph is a new science and one that is likely to contribute a great deal to human welfare. Though seismology is still in its infancy, it is already possible by means of the seismograph to detect the approach of not only volcanic eruptions and earthquakes, but also of typhoons and other disastrous storms. Typhoons, by moving the water of the sea, set up in the earth vibrations of sufficient intensity to be recorded by seismographs located on neighboring shores.

Japanese seismologists have been particularly successful in these predictions, saving great losses of shipping and human life. In view of the expected development of seismology and its great practical importance, the Congress gave particular attention to the improvement and extension of methods of recording earth movements and also to increasing the number of observing stations and to the re-location of some already established. Further, since the proper interpretation of seismographic observations depends upon rapid and ready communication between various observing stations, steps were taken to organize a central bureau in which all such reports could be successfully and promptly coördinated and in turn distributed to the various observers. While it is not true that volcanic activity and earthquake phenomena are necessarily intimately related, it, nevertheless, is true that these phenomena are so correlated as to warrant the establishment of joint observatories in volcanic districts. Such an observatory has been established on the Island of Hawaii near the crater of Kilauea. Although this station has been in operation but a few years it has already contributed greatly to our knowledge of volcanic phenomena. In view of this, special recommendations were made for the establishment of similar observatories wherever there are active volcanoes in and around the Pacific. A practical phase of this general subject is the study of the destructive effects of earthquakes to determine the proper methods of building construction and engineering enterprises so as to render them less liable to catastrophies when earthquakes occur.

The biological section gave particular attention to the conservation of natural resources. Many species of fish and other marine animals are being exterminated from Pacific waters. The complete loss of these would be a great detriment to the welfare of all the peoples now dependent on them. Since it is obvious that successful measures for the protection of marine life must be based upon an exact knowledge of the life histories of the various species, it follows that biological research in these fields is of the greatest practical importance. To this end recommendations were made to the various governments in and around the Pacific, urging the creation of marine biological stations at convenient points and the organization of a systematic survey of the whole region, with particular attention to economic problems in fisheries. Although an international body, the Congress regarded this question of such urgency that some existing agency or institution within one of the nations concerned should be designated as the leader to organize such a survey as an international project. The choice fell upon the National Research Council of the United States.

The problems of distribution of the land flora and fauna of the Pacific Islands are also of the greatest theoretical significance. For example, when certain wild plants whose chief range of distribution is upon one of the adjoining continents are found upon a few of the islands far out in the Pacific, we wish at once to know how these plants got there. But even more interesting problems are connected with the frequent lava flows in Hawaii and other islands where volcanoes are active. When a volcano ejects a mass of lava this flows down over the slopes of the mountain and the surrounding country and when cooled presents a new surface devoid of any living thing. Plants and animals, however, gradually appear upon this surface, with the repetition of all the essential steps in the creation of soil and the formation of the earth's surface as we know it. Thus such spots present great opportunities for research not only of theoretical but of practical value, for the time will come, in the days of diminishing returns from the cultivation of the soil, when we must know what plants are able to grow in waste places and the steps necessary for the production of new soils.

Another group of problems of great immediate importance includes those of the racial characteristics of the races of peoples bordering on the Pacific, and of the mixture of these races. Since the Pacific area is the meeting place of the East and the West, there is no better field for studying the scientific bases for the compatibility or incompatibility of mixtures of peoples which differ greatly in tradition, in type of culture, and in stock, and which have been brought only recently into intimate contact with each other.

NEW EXPEDITIONS

That the Pan-Pacific Congress is supported by a growing interest in the field of racial research is indicated by a recent substantial gift from Mr. Bayard Dominick to Yale University and the Bishop Museum of Honolulu, exclusively for research on the culture and racial characteristics of the Polynesians. These resources make possible field exploration upon a large scale. Prof. Herbert E. Gregory has been ap-

pointed the director of these and other researches under the joint authorization of Yale University and the Bishop Museum. When the Pan-Pacific Congress assembled in Honolulu it was requested by the trustees of the Bishop estate, who administer the Bishop Museum, to formulate a specific plan for research in the Pacific, particularly in Polynesia, which they might adopt as their program, but with the understanding that such a plan should be so drawn as to encourage other institutions and investigators to come into the field on a coordinate basis. The Bishop Museum is now sending out a number of men in parties of three, each party being made up of an ethnologist to study the present culture of the natives, an archaeologist to study the remains of past native life by working in ruins, tombs, and other debris of past cultures, and finally, a botanist to give particular attention to the plants used by the natives, since the origin of these will throw light upon the past history of the Polynesians. The following newly appointed members of the survey are now in the field: For the Marquesas Islands, Dr. E. S. Handy, ethnologist; Dr. Ralph Linton, archaeologist; Dr. Forest B. A. Brown, botanist. For the Tonga Islands, Dr. E. W. Gifford, ethnologist; William C. McKern, archaeologist; and for Austral Island, Dr. R. T. Aitken, ethnologist, and John F. G. Stokes, archaeologist. The botanists for the two latter parties are still to be appointed.

The only other institution taking an active part in this field is the American Museum of Natural History of New York. It is coöperating directly with the Bishop Museum in the Bayard Dominick Survey by assuming responsibility for the racial problem in Polynesia. This work is under the immediate direction of Dr. L. R. Sullivan, who will give his attention to the racial characteristics of the Polynesians, but will extend the work later to include studies of other races in the Pacific, giving particular attention to the subject of race mixture.

In addition the American Museum of Natural History has organized a survey of bird life in the Pacific upon an unprecedented scale. As projected, the work will cover a term of ten years. A number of parties will be maintained in the field, equipped with small vessels fitted out with laboratories for working over the specimens as they are collected. The undertaking is under the direction of Dr. Frank M. Chapman, the famous explorer and student of bird life, long associated with the American Museum. The great problem in the bird life of the Pacific is the distribution and local evolution of the different species. From our superficial knowledge we know that in some of the islands birds of the same species have changed the form of their beaks according to the food available in the respective islands. Such local adaptations to environment promise to be one of the most important points developed in this investigation. Islands offer better opportunities for the modification of species than continents because in the former we have many isolated land masses where birds, for example, may live for centuries without receiving a single foreign visitor of their kind. This is rarely the case upon a continent where the constant crossing within the species tends to drown out all new developments.

The work of the Bishop Museum and of the American Museum of Natural History will be so adapted as to conform to the new ideal laid down by the Pan-Pacific Congress. Each institution will direct its own operations, but will so adjust its program as to coördinate its work with the recommendations of the Congress and so coöperate to the common end. It is hoped that institutions in Canada, Australia, New Zealand, and Japan will enter this field with similar equipment and that the governments of these countries will take immediate steps to carry out the recommendations of this Congress concerning oceanographic surveys.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

A GENERAL SINKING OF SEA-LEVEL IN RECENT TIME

In the Proceedings of the National Academy of Science for May, 1920, Mr. Reginald A. Daly of the Department of Geology of Harvard University presents an interesting paper in which he considers the subject of the general sinking of sea-level in recent time.

Nearly twenty years ago the hypothesis of a recent, negative movement of sea-level first presented itself to Mr. Daly while he was engaged in the correlation of post-Glacial elevated strands in Labrador and Newfoundland with those of Quebec. The highest strand mapped between Newfoundland and Nachvak Bay, 500 miles to the northwest, was found to be strongly warped, like the highest strand from Newfoundland to Massachusettts. On the other hand, the lowest emerged terrace along the shores of the Gulf of St. Lawrence was seen to be conspicuously level throughout a distance of 300 miles or more below Quebec City. This apparent uniformity of level prompted the question whether this particular strand had been abandoned by the waves because of a sinking of general sea-level. For lack of accurate leveling, correlation with the more closely studied, lowest beaches of Labrador was impossible, and with the data in hand serious belief in the hypothesis of a eustatic change was withheld.

However, that explanation was recalled by the discovery of new facts during recent field studies on the shores of New England, Florida, and the Samoan Islands. Meantime Goldthwait had made a careful study of the St. Lawrence strand, to which he gave the name "Micmac terrace"; and the results of his leveling agree so well with those made in the other regions mentioned that the suspicion of past years became a hypothesis deserving more attentive consideration.

In his account of the Micmac terrace, Goldthwait noted the nearly uniform level of its inner edge at about 20 feet above high tide, as well as its relatively great strength and continuity, with width varying from a few feet to 1.5 miles or more. Though only a part of its width is due to wave-cutting and though the formations affected are weak, the higher level of the sea must have been steadily kept for a large fraction of post-Glacial time. Farther east in the Gulf of St. Lawrence, on Anticosti, and again in Nova Scotia, Twenhofel has found wide terraces at about the same level. A similar feature characterizes the coast of Maine, as emphasized in the folios and monographs of the United States Geological Survey.

Mayor had also found wave-cut rock benches, about 8 feet above high tide on all sides of Tutuila, the largest island of American Samoa, and Mr. Daly himself has found very fine wave-cut benches at 8 to 10 feet above high tide on Aunuu and Tau, and others at the same general elevation on Olosega Island, 7 miles west of Tau. Explanation by local uplift was at once seen to be highly improbable, for crustal uplift of such uniformity is unknown to geology.

Eight or ten feet of bench elevation does not, however, measure the total of recent emergence in Samoa. At several points in Tutuila large sea-caves were found. Their floors varied in height from 14 or 15 feet at their mouths to 25 feet at the back walls of the caves. Many caves of similar form and cut in similar rocks are being made by the surf of the present day. The lower lips of these newer caves are

characteristically 4 to 6 or more feet below high-tide level and the floors rise inward to heights of a few feet above high tide.

The hypothesis of a eustatic shift must obviously meet the test of matching the facts observable on the shores of every continent and of most islands. A specially instructive example is seen in the agreement of the lower Cape May terrace of New Jersey and Pennsylvania, the Talbot terrace of Maryland (marine part), the Satilla terrace of Georgia, and the lower Pensacola terrace of Florida in age, height and strength of development, both among themselves and with the other terraces above mentioned. The Pensacola-Satilla terrace alone keeps a practically uniform set of levels (maximum about 20 feet) for an airline distance of 500 miles; the explanation of its emergence by crustal uplift seems hardly credible.

A second test naturally inheres in the expectation that the deleveling should be synchronous in all parts of the ocean. Observers dwell on the recency of the sea-level shifts registered in all of the cases compiled. Fossils from the St. Lawrence, Scottish, Irish, Cuban, Patagonian, New Zealand, Australian, Funafuti, Murray Island, New Jersey, Maryland, Georgia, and Florida beaches, reefs, or coastal plains belong to species now living in the adjoining seas, or, exceptionally, to species now living in slightly warmer water. Great recency is also shown by the relatively small damage done by erosion to the strand-marks, except in the case of those exposed to powerful surf. The beaches of the higher latitudes are clearly post-Glacial and also of later dates than the post-Glacial uplifts following the melting of the ice-caps.

Simultaneous emergence of the many separate regions is the more credible because of the similarity in the histories of their respective coasts before emergence. Repeatedly one encounters the description of terrace, bench or beach near the 20-foot level as the best developed, the most conspicuous, of the most persistent in areas characterized by "raised" strand-marks.

In conclusion the most promising idea appears to be that a few thousand years ago there was an increase in the volume of the existing, non-floating glaciers. If the Antarctic ice-cap were then thickened to the average amount of about 700 feet, an average sinking of the sea-level to the extent of nearly 20 feet would be inevitable. In favor of this suggestion would be evidence of a world-wide oscillation of climate like that which seems to have affected the Christiania region in recent time. If the whole earth was, in the Tapes period, a little warmer than now, less water may have been taken from the ocean to constitute the ice-caps; sea-level was a little higher than at present. The oscillation as a whole would be but an incident in a series of climatic and oceanic changes which began with the opening of the Glacial period.

THE NATURE OF ANIMAL LUMINESCENCE

IN a paper read before the American Philosophical Society at its meeting in Philadelphia, April 20-24, 1920, Prof. E. Newton Harvey of Princeton University presents and discusses the extremely striking results obtained by him in the study of *animal luminescence and stimulation.* Professor Harvey finds that the production of light by animals is due to the burning or oxidation of a substance called luciferin in the presence of an enzyme or catalyst called luciferase. This light-production resembles the ordinary artificial methods of illumination by burning in that oxygen is as necessary for animal luminescence as it is for the light of a lamp or tallow candle. It differs in that water is absolutely essential for the light production and no carbon dioxide or heat is produced, at least no carbon dioxide or heat is produced at all comparable to that formed during the burning of such substances as tallow, either in the form of a candle or as food, to supply heat and energy for the body. Light production by animals differs also from light produced by combustion in that the oxidation product of luciferin, oxyluciferin, can be easily reduced to luciferin, which will again oxidize with light production. The reaction is reversible and appears to be of this nature—luciferin $+O \leftrightarrow$ oxyluciferin $+ H_2O$. The difference between luciferin and oxyluciferin lies probably in this, that the luciferin possesses two atoms of hydrogen which are removed to from H_2O when the luciferin is oxidized. The H_2 must be added to reform luciferin. Whether the reaction goes in one direction or the other depends, among other things, on the concentration of oxygen and the presence of a reducing agent. In a mixture of luciferin, luciferase, reducing agent and an abundant supply of oxygen, the reaction goes from left to right (with production of light) to an equilibrium. On removal of oxygen the reaction goes in the right to left direction with reformation of luciferin. Thus, while a firefly is flashing, oxyluciferin is produced and between the flashes oxyluciferin is reduced and is now ready to be again oxidized with light production. One may figuratively describe the firefly as a most extraordinary kind of lamp which is able to make its oil from the products of its own combustion. Not only is it most efficient so far as the radiation (being all light) it produces is concerned, but also most economical so far as its chemical processes are concerned. The above reactions can be demonstrated in a test tube with a mixture of oxyluciferin, luciferase and ammonium sulphide. The ammonium sulphide is probably represented in living cells by reducing enzymes or reductases. If such a test-tube is allowed to stand, oxyluciferin is reduced to luciferin which will luminesce only at the surface of the liquid in the test-tube in contact with air. When the tube is agitated so as to dissolve more oxygen of the air the liquid glows throughout. Even a gentle knock or "stimulus" to the tube is sufficient to cause enough oxygen to dissolve to give a momentary flash of light which is strikingly similar to the flash of light given by luminous animals themselves on stimulation. This suggests that when we agitate a luminous animal or when the luminous gland cells of a firefly are stimulated through nerves with the resultant flash of light, in each case the stimulus acts by increasing the permeability of the surface layer of the cells of oxygen. This then upsets an equilibrium involving the luciferin, luciferase, oxyluciferin, oxygen and reductase within the cell, with the production of light and formation of more oxyluciferin. So long as the luminous cell is resting and unstimulated the tendency is for reduction processes to occur and luciferin to be formed. It must be pointed out that not all sorts of stimulation can be explained in this way, as the stimulation of muscles or nerve fibers may take place in the complete absence of oxygen.

THE COMPONENTS AND COLLOIDAL BEHAVIOR OF PROTOPLASM

AT the 1920 general meeting of the American Philosophical Society held in Philadelphia in April, Dr. D. T. MacDougal, director of the Desert Laboratory of the Carnegie Institution, Tucson, Arizona, presented an important paper on "The Components and Colloidal Behavior of Protoplasm," of which the following is a summary: The living matter of plants is composed chiefly of mucilages and albuminous compounds in varying proportions mixed in the form of an emulsion or as a jelly. The molecules of solid matter are aggregated into groups which also include a number of molecules of water. Growth consists of the absorption of additional water to these groups, with more solid material being added at the same time, the process being termed hydration. The resultant increase may be detected by determination of increased dry weight, or measured as increase in length, thickness or volume. More exact studies in growth have become possible by the establishment of the fact that mixtures of 25 to 50 per cent mucilage and 50 to 75 per cent albumin show the hydration reactions of cell-masses of plants. It is also found that certain amino-compounds, such as histidine, glycocoll, alanin, and phenyl-alanin which are known to promote growth also increase the hydration of the *biocolloids* as the above mixtures are called. Following these empirical tests which have defined the character and field of research upon growth, measurements are now being made of the action of various ions or

substances upon the components of protoplasm. Thus the strong metallic bases, potassium, sodium and lithium, exert a limiting action on hydration of carbohydrate (agar) in hundredth normal solution according to their position in the electromotive series, potassium being the strongest and reducing swelling most. Rubidium, however, did not take its place at the head of the list in the single series of tests made for reasons we are not able to describe. At dilute concentrations all these bases promote hydration, an effect also produced by amino-compounds. The inclusion of substances in a liquefied colloid, afterwards dried, produce a hydration effect different from that which results from placing the substance in the water in which the biocolloid may be placed. This fact has wide significance in the physiological action of cell-masses. Renewal or replacement of hydrating solutions may result in pulsations or rapid swellings, followed by slow shrinkages or retractions. Gels similar to those entering into living matter may take on structure by which small masses or sections may display highly differentiated action, increases in size and changes in forms after a manner which presents important possibilities in the behavior of cell-organs. —From Science, June 11, 1920.

THE EFFECT OF HIGH TEMPERATURES ON FRUITS

The *Botanical Gazette* for April, 1920, contains an article by Messrs. Overholser and Taylor describing the rather startling results obtained by them in the study of the effect of high temperatures on the ripening and deterioration of pears and apples.

The authors give the following summary of their results and conclusions:

When contrasted with temperatures between 70 and 85°F., temperatures of 87.7 to 110°F. caused an appreciable delay in the ripening of green first crop Bartlett pears.

The retardation of ripening was directly proportional to the increased degree of heat within the limits of 87 and 104°F.

The amount of delay in ripening of green first crop Bartlett pears of the different temperatures when contrasted with 70°F., or room temperature, was as follows: 85°F., no retardation; 87.7°, 5 days; 94°F. and 104°F., 13 days.

Second crop Bartlett pears, placed at a temperature of 101°F. and surrounded by a relative humidity of below 50 per cent, remained unripe 4 weeks after similar pears had become fully ripe at room temperature and humidity.

The relative humidity does not seem to be a significant factor in checking the ripening processes. Its effect is in lessening or permitting wilting, depending upon whether the relative humidity surrounding the fruit is high or low.

The flavor of the pears subjected to those temperatures higher than 85°F. was not normal. There was a slight acidity, and the sweetish taste and juiciness were lacking.

Temperatures above 110°F. result in a more rapid ripening and consequent breakdown of the tissue than do any of the lower temperatures, down to average room temperatures.

As would be expected, there was a comparatively large loss from rot with the fruit kept at high temperatures and surrounded by high relative humidity.

A possible explanation of the effects of high temperatures may lie in the influence upon the enzymes. Temperatures approaching the probable minimum (around 28°F.) on the one hand, and the probable maximum (around 110°F.) on the other, might result in a reduction of enzymatic activities of the fruit and a consequent retardation of the ripening processes; while with the optimum temperatures (70-85°F.) the enzymatic activity would be most marked, and hence the ripening most rapid.

If the Bartlett pears have nearly reached a stage of complete ripeness, the temperatures above 70°F. do not check the ripening process. On the other hand, the ripening and breakdown are more rapid with each marked rise in temperature.

Unripe Easter pears behave in a manner comparable to the Bartlett when placed under similar conditions of high temperature and relative humidity.

The process of ripening with Yellow Newton apples is not delayed by temperatures above 32°F. The ripening takes place with increased rapidity with each appreciable rise in temperature above 32°F.

The experiments suggest that with an excessively hot season during the time of ripening, Bartlett and Easter and possibly other pears might be allowed to remain on the trees somewhat longer than with a normal season.

For Yellow Newton and no doubt other varieties of apples, which are to be stored any length of time, the necessity of quickly cooling after harvesting is emphasized.

The author considers that the practical applications of the data presented are somewhat limited, but the facts may be of value some years and in certain sections in connection with the time of picking Bartlett pears. For example, as a rule during the hottest seasons the growers have felt a greater necessity for earlier picking than when the season is normal at the time of ripening. In view of the results obtained, it may really happen that the ripening of the pears is delayed by the excessively hot weather, and would mean that the fruit might well be allowed to remain on the trees longer than would be the case in a normal season. If all varieties of apples behave as do Yellow Newton, high temperatures do not delay ripening. Instead, up to the point of tissue destruction by heat, the higher the temperature the more rapid the ripening. This emphasizes the necessity of hurrying into low temperatures apples which are to be stored for any length of time.

THE NUTRITIVE VALUE OF PEANUT FLOUR AS A SUPPLEMENT TO WHEAT FLOUR

Messrs. C. O. Johns and A. J. Finks of the Protein Investigation Laboratory, Bureau of Chemistry, United States Department of Agriculture, Washington, give, in the *Journal of Biological Chemistry*, for July, 1920, the following summary of results obtained by them in the study of the Nutritive Value of Peanut Flour as a Supplement to Wheat Flour.

A diet containing bread made from wheat flour (74 per cent extraction) when fed to albino rats as the only source of protein and water-soluble vitamine, together with an adequate inorganic salt mixture and butter fat, produced only about one-third to two-thirds of normal growth.

Bread made with a mixture of 25 parts of peanut flour and 75 parts of wheat flour furnished adequate proteins and water-soluble vitamine for normal growth. A similar bread containing 15 parts of peanut flour and 85 parts of wheat flour contained proteins and sufficient water-soluble vitamine for growth at very nearly the normal rate.

Wheat flour (74 per cent extraction) contains sufficient water-soluble vitamine for the normal growth of albino rats.

The proteins in the peanut bread were utilized almost twice as well as those contained in the wheat bread.

A SIMPLE METHOD OF MEASURING RESPIRATION

At the 1920 general meeting of the American Philosophical Society in Philadelphia in April, Dr. W. J. V. Osterhaut, professor of Botany in Harvard University, presented an important paper on "A Simple Method of Measuring Respiration," whereby determinations can be made at frequent intervals (as often as once every three minutes). The application of this method to the study of anesthesia shows, in Professor Osterhout's opinion, the incorrectness of the theory of Verworn, according to which anesthesia is a kind of asphyxia, due to the inhibition of respiration by the anesthetic. In the study of antagonism it is found that the antagonistic substances may increase or decrease respiration, but when properly combined they show little or no interference with normal respiration. The study of the action of acids and alkalies shows that these substances may increase or decrease respiration and that the effect varies greatly with different organisms.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

GAS APPLIANCE INVESTIGATION

RECENTLY the attention of the public has been directed to the wasteful way in which natural gas is at present being used. Not many years ago our gas wells were looked upon as constituting an almost unlimited source of supply of gas for all purposes. As a consequence, the most wasteful methods were in many cases employed in the utilization of this natural resource. Now, however, scientific men have pointed out that this is a very limited natural resource and one which should by all means be conserved and used only for those purposes for which it is best adapted, employing for other services artificial gas, which in many of these cases is practically as satisfactory.

During the war the Bureau of Standards was called upon by numerous cities and States to investigate natural gas conditions and to point out means for improving the situation. This has led to a very thorough investigation of the whole natural gas problem and particularly to a study of the types of burners employed. It is probably not generally known that most gas burners, such as are used in our homes, are very inefficient. The proportions of air and gas are seldom the best possible, with the consequence that the maximum number of heat units are not obtained from combustion of a given quantity of gas. This investigation of gas-burner design and operation was begun last year in coöperation with the Industrial Fuel Committee of the American Gas Association. It has been actively continued throughout this year, and the points studied have included the proper design of air shutter, gas orifice, and burner throat to give the maximum injection of air under ordinary conditions. Some months have been spent in designing and developing suitable apparatus for making the necessary measurements of the air and gas. While progress in this direction seemed slow, it was time well spent, as the equipment finally developed proved so satisfactory that the results are now obtained with unusual rapidity.

Work has been done on experimental burners representing a wide variation in dimensions and an extensive report has already been presented to the Industrial Fuel Committee. This report covered primarily work in connection with industrial burners but the urgent need for conservation of natural gas service, as supplied to households, suggested the desirability of extending this investigation to types of burners in domestic use. Since transportation of sufficient quantities of natural gas to Washington was not practicable, the Bureau of Mines kindly furnished space in its Pittsburgh Experiment Station and work has already been commenced there to find what range of efficiency is actually obtained in the use of natural gas and what degree of improvement is practicable.

This work has already progressed far enough to bear out the statements made above, that many appliances at present in use are very low in efficiency and that great improvement in this respect can readily be made. Specific tests have shown that equipment which now makes use of from 10 to 30 per cent of the heat of the gas can be made to utilize 30 to 50 per cent.

Results of great importance have also been obtained in the design of natural gas burners to operate on low pressures. In very cold weather the gas pressure is apt to fall for various reasons, rendering the usual gas appliances practically useless. This investigation has shown that burners can be so designed as to operate well on natural gas at low pressures, such as are used with the common quality of manufactured gas, and it is possible that an improvement in service might be made by installing gas regulators which would supply gas at a low and uniform terminal pressure. As the adoption of this plan would require considerable changes in gas distributing systems, valued at millions of dollars, it will undoubtedly be some time before it can be definitely recommended as desirable.

EFFECT OF HEATING THE INLET MANIFOLD ON AUTOMOBILE ENGINE PERFORMANCE

OVER a year ago, the Committee of the Society of Automotive Engineers on the Utilization of Present Fuels in Present Engines decided to promote "a more miles per gallon" movement, by publishing a report on the economy to be secured by applying the correct amounts of heat at the intake manifold of the conventional design of automobile engine. This Committee prepared a report dealing with the present state of the art as regards hot spots, heated air, etc., and then decided to supplement this by a special series of experiments to be conducted at the Bureau of Standards.

This work was undertaken early in the summer, and included measurements of engine performance under conditions of both steady running and rapid acceleration with different temperatures of the intake charge secured by three different methods: (a) The hot air stove supplying heated air to the carburetor; (b) the uniformly heated intake manifold, and (c) the hot spot manifold. The Bureau was fortunate in securing through the courtesy of one of the large automobile builders a 6-cylinder automobile engine of standard design, the construction of which was such as to permit of the ready changing of the intake and exhaust manifolds to suit various conditions. The engine was mounted in the Bureau's laboratory, connected to a 50 hp. Sprague dynamometer as well as to a flywheel consisting of a 33-inch steel disk ½ inch thick mounted on the dynamometer shaft. The inertia of this uywheel added to that of the dynamometer armature was figured as being about equal to the inertia of a motor car weighing about 3,500 pounds when on direct drive with a gear ratio of 5 to 1 and using 32-inch wheels. This inertia disk was used only in connection with special acceleration tests and was removed for the constant speed runs to avoid unnecessary windage and strain upon the shaft.

An interesting portion of the test consisted in motion pictures of the appearance of the air-fuel mixtures in the manifold under different conditions of temperature, speed, and throttle opening. In order to permit a visible observation of the fuel, the T portion of the manifold was made of Pyrex glass so supported as to be free from the stresses caused by the rest of the manifold and the carburetor. It was interesting to note that in but one of the runs conducted while this manifold was in place was the interior of the same completely dried. This condition was obtained only with great difficulty by the direct application of the flames from two brazing torches to the glass T. It was impossible to dry the walls of the manifold solely by heating the air entering the carburetor to as high a temperature as possible, 240°C (464°F.). At this temperature the walls were still covered with a rather thin oily film which could be seen to creep slowly toward the intake ports. Liquid particles in the airstream were carried against the upper part of the manifold above the carburetor throat and kept this portion wet at all times. When the T was heated with the brazing torch a great difference was observed in the

ease with which heat could be supplied to the liquid on the walls. The liquid striking the top of the manifold had sufficient velocity to make good thermal contact with the wall and hence was readily evaporated. On the bottom of the horizontal portion of the manifold, where the puddles of liquid were relatively deep, the vapor formed would insulate the liquid above it from the wall, thus making evaporation more difficult. When the glass wall reached a high temperature, the liquid fuel assumed the spheroidal state and behaved as water does when dropped on a very hot stove. The liquid which collected on the lower wall of the manifold came from the inside surface of the vertical section of the T. and was finally eliminated by heating this section instead of the spots where it afterward collected. The amount of heat necessary to vaporize the liquid on the walls when no heat was applied to the inlet air was surprising. The full blast of a ½-inch torch would just dry the top of the manifold. If the torch were removed for as much as five seconds the wall would again become wet. Fog was present in the mixture stream only when the intake air temperature was below about 90°C.

After conducting these preliminary tests with the glass manifold and securing motion pictures of the appearance of the air-fuel mixture, the main investigation was begun. The first series of tests included runs with a manifold using an exhaust jacket. As the points in which the average car owner are most interested are low fuel consumption and rapid acceleration, the problem was essentially to determine how the attainment of this result is influenced by changes in the amount of heat furnished the intake charge or in the method by which this heat is supplied. From these measurements it was decided that the fuel consumption per indicated horsepower remained substantially the same throughout all the charge conditions that were investigated. While differences in consumption on the brake horse-power basis are often large, on the indicated horse-power basis they are in general within the limit of experimental error. The curves plotted as a result of this work show differences of less than 4 per cent with three different methods of heating with intake port temperatures ranging from 48 to 96°C. (118.4 to 204.8°F.), and with carburetor air temperatures from 30 to 90°C. (86 to 194°F.). It may be concluded, then, that over this range the method and amount of heating to be employed can be governed by its effect upon the acceleration of the engine with the assurance of producing no appreciable change in economy of operation.

In the acceleration tests, a dynamometer load was selected to correspond with that of a car at about 45 miles per hour with full throttle. This load was determined by running the engine at full throttle and 2,400 r.p.m. and noting the position of the dynamometer control resistances. The engine was then idled at a slow speed with the resistances set as noted and the throttle suddenly opened. Under these conditions the inertia load of the flywheel corresponded to the inertia load of the car, and the load speed characteristic of the dynamometer approximated its wind and frictional resistance. Prior to the acceleration test the engine was run at full throttle and 650 r.p.m. and observations were made of power, fuel consumption, air flow, pressures, and temperatures. The acceleration run was then made by suddenly and completely opening the throttle and at the same time a chronographic record was taken of time and engine revolutions. When the speed of the engine reached 1,800 r.p.m. the throttle was closed and the run repeated. These runs covered at least three mixture ratio settings. With a given amount of heat supplied to the intake manifold, this was then changed and the runs repeated.

In conclusion, it may be stated that this investigation seems to show (1) that at constant speed, mixture ratio, and power output, the fuel consumption in pounds per brake horse-power is independent of the temperatures and methods of heating the intake charge within the range covered by this work. (2) The rate at which an engine will accelerate with a given mixture ratio or carburetor setting is markedly affected by the amount of heat supplied and its method of application. Within the limits of this work, the greater the amount of heat supplied to the charge and the higher its temperature at the intake port, the more rapidly the engine will accelerate.

ANALYSIS AND METALLOGRAPHIC EXAMINATION OF SAMPLES OF ANCIENT ARMOR

NEARLY every one has always felt a certain amount of interest in studying the processes employed in bygone times for the production of various materials, some of which appear to excel those known today. The name of Damascus is, for example, a synonym for the keenest of sword blades. It is well known to scientists, however, that very often the excellence of the finished products was due more to the employment of very high-grade raw materials than to any special merit of the production processes.

Recently the Metropolitan Museum of Art in New York City submitted to the Bureau of Standards a number of samples of armor of various types and made at different dates, all of it being many hundred years old. The Museum requested that these samples be examined with a view to determining the processes employed in the manufacture of the armor. As some of the samples were badly rusted on both surfaces, it was somewhat difficult to secure enough material for certain of the analyses. The carbon determination had to be made across the entire cross-section of the material in each case, since the metal was so thin and corroded that samples could not be obtained from the different layers.

In examining the specimens microscopically, they were cut down and polished in such a way as to expose the various layers of which the finished piece consisted. Both chemical analysis and microscopic examination indicated that the process used in the production of the armor was very similar to our method of producing wrought iron. This is generally known as the old cementation process. The metal was then carbonized and hammered into thin sheets. These differed considerably in hardness and probably in carbon content, though, as before stated, the latter could not be determined chemically, owing to the thinness of the sample. These various sheets were then welded together, hammered into the desired shape and the whole quenched to produce the final hardening effect.

All samples examined contained small amounts of copper, but this was in all probability present in the original iron ore. The examination proved the purity of the materials used.

A DISTANT-READING GERMAN AIRPLANE COMPASS

THE Aeronautic Instruments Section of the Bureau has probably the most complete collection of foreign airplane instruments in this country. Many of these have been received quite recently from a representative of the Bureau who spent some time in Europe. Among the German instruments recently added is a Bamberg distant-reading compass which appears to possess several features of interest and merit. The compass depends for its operation upon the characteristic of selenium which causes it to vary its electrical resistance with any change in the intensity of the illumination falling upon it. In the installation on an airplane, the compass itself is mounted in the tail as far as possible from all disturbing magnetic influences. The bowl of the compass contains two electric bulbs diametrically opposed which throw their rays through a lens. The latter concentrates the light upon two corresponding selenium cells mounted upon a bridge extending across the top of the bowl. In place of the ordinary card employed on the usual form of compass a metal disk is attached to the magnetic element with a slot cut in it in such shape that the disk acts as a blind for the illuminating element. Thus the intensity of the illumination falling on the selenium cells is varied in accordance with the position of the magnetic element carrying the disk. An electric circuit connect the cells with an ammeter. In this way the readings of a compass are indicated at any distance from the instrument. A mechanical connection to the compass bowl allows the navigator to direct the pilot on a given course by rotating the bowl.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

PREVENTING SUGAR DETERIORATION

It may not be known generally that certain molds and bacteria cause an appreciable annual loss of sugar by consuming the sucrose in the raw sugar. It is true that the loss upon any single barrel is far too slight to be detected by any other than laboratory methods; but it is possible for these micro-organisms to consume a half teaspoonful or so during summer storage. The usual source of these molds is the air, which always contains numerous micro-organisms, and each individual mold if it falls upon an object which can supply it with sufficient food can reproduce 300,000 or more individuals of the same species in less than a week. This reproduction takes place only when sufficient moisture is present, and it is the tendency of sugar to absorb moisture in humid climates or on ocean voyages that makes it an ideal medium for the growth of these molds. Sugar is often stored for some time in refineries where, owing to temperature changes, there is some condensation of moisture.

The amount of the Cuban crop, which is believed to be destroyed by molds, is approximately 1 per cent or nearly 70,000,000 pounds annually, which, at the rate of consumption in the United States, would supply more than 870,000 persons for one year. At the Louisiana Sugar Experiment Station, Nicholas Koploff has devised a method for preventing the molds and bacteria from causing this destruction and has also determined which micro-organisms are most greedy. This has led to the development of a method by which the keeping quality of sugar may be determined in advance by identifying the molds and referring to a chart.

The method recommended to prevent sugar deterioration is the substitution of dry, or superheated, steam for water in the final process of washing in the drums or centrifugals in which sugar is dried. As the centrifugals whirl air is drawn in from the bottom, carrying with it some of the mold spores. At the same time the wash water is pretty sure to carry molds and bacteria. Tests on the new process have shown that dry steam is successful in killing over 99 per cent of the molds and bacteria, and while this practice is not essentially new, the results now on hand show that there is a direct practical value in eliminating these small losses which in the aggregate are a considerable factor, especially at the present price of sugar.

Bulletin No. 166 of the Louisiana Experiment Station, by Koploff and Koploff, discusses the deterioration in the manufacture of cane sugar at length, and the chart to which reference has been made accompanies Bulletin No. 170 of the same station. The reader is also referred to the September numbr of the *Journal of Industrial and Engineering Chemistry.*

MOLECULES AND MAN

This is the subject of a pamphlet by Dr. Robert E. Rose which was distributed by one of the large chemical and dye companies at the recent National Exposition of Chemical Industries and deserves special mention because it presents in non-technical language, and with great clearness, some of the features of synthetic chemistry which are most difficult to present in a way to interest the non-technical reader.

Certainly when the first Chemical Exposition was organized during the war no one would have attempted this explanation at such an exhibit as that where the booklet in question was distributed and which was devoted to a presentation of some of the steps in the synthesis of dyes by means of groups of models depicting the molecules of substances as they are conceived to be constituted by the organic chemist. It must be that an increasing number of the public have come to appreciate matters of this kind and have informed themselves to the point where an intelligent interest can be taken in such an instructive exhibit. It seemed certain that even the casual observer could derive a better understanding of what the dye industry is about from the examination of these models than by seeing an array of gaily colored fabrics which after all mean little in themselves.

But, to refer again to Dr. Rose's presentation, he points out that in inorganic chemistry the chemist can only set the elements free as in the case of metals where thus far it has not been found possible to devise a metal which does not occur in some form in nature; but in the realm of organic chemistry it is the province of the chemist to make new kinds of matter, and to do so he must change each least unit of the substances he uses for his building. These least units are known as molecules, and the organic chemist must learn how to build them up, break them down, or rearrange the atoms of which they are composed, and when that is done the original substance disappears and another takes its place. Dr. Rose uses the simile of the letter and the word to convey his meaning, saying that molecules are like words and atoms are like letters. Thus one may think of the dye indigo as a mass of units each of which is the word indigo.

"In making this word (molecule) the chemist uses simpler words (molecules); some of only one letter, but still a word like 'I.' He cannot use single letters that do not form words because nature only furnishes perfect molecules, though these are sometimes made of only one kind of matter. Given these simpler molecules which may be represented as

I-gin-I-nod-dog-I

he puts them through processes which loosen the atoms from each other and cause them to become rearranged in a new order just as the words above can be regrouped to give

Indigo-Indigo."

Thus the chemist may be said to be engaged in a kind of a game, endeavoring to arrange groups of certain atoms in as many different kinds of molecules as possible. Limiting him to carbon, oxygen, nitrogen, and hydrogen he has already produced more than 100,000 different molecules which is a greater number than the words that could be formed from these four letters. The chemist goes so far as to use letters when indicating his molecules on paper, and these letters are arranged in strange fashion, so that they tell the chemist the relationship of the substance to other substances and may even indicate to him some of the characteristics of the substance and the possibilities of changing it into still other substances. In writing such a symbol the chemist uses lines to indicate bonds by which the atoms or letters are held in peculiar ways in the molecule or the word.

Dr. Rose has given us a new definition for chemical industry when he says chemical industry is "the rearrangement of atoms to give more useful products than the molecules in which the atoms are supplied."

When one remembers that these molecules are after all the finished product which the manufacturing chemist has for sale it is astonishing to think how small these molecules are and how many of them are sold at a reasonable price. From work which has been done in determining the size of molecules it has been estimated that a pound of a dye called Pontamine Black EX contains about forty sextillion molecules, each one of which is composed of seventy-nine atoms and every atom

in its place in proper relation to the other atoms, and all for $1. If these molecules were beads and strung together they would reach a distance such that light traveling 196,000 miles per second would require twenty-one years to traverse it. When using this dye upon hosiery one square inch of fabric of average weight absorbs twenty quintillion molecules of dye.

The booklet embodies a number of these letter groupings, which picture the molecules to the chemist, and show how he succeeds in adding a few letters here and there in the transformation of raw materials into intermediates and these intermediates into the dye.

Modern civilization is greatly indebted to the organic chemical industry, and surely nothing should be allowed to stand in the way of firmly establishing such an industry in our country. This industry provides us with many things unavailable in the days of our great grandfathers and is responsible for our various anesthetics, many of our medicinal and pharmaceutical preparations, synthetic perfumes, disinfectants, and fibers which range in size from horsehair to those smaller than the fibers of natural silk. Today the organic chemist designs molecules to fight diseases just as he arranges atoms in a new way to produce a new dye. Materials such as adrenalin, formerly recovered wholly from natural sources by intricate processes involving great cost, are now articles of manufacture, and many of the apparently hopeless problems involving almost incredible nicety of chemical action lie within the grasp of chemical therapeutics. To encourage exhaustive research such as that required for these accomplishments the chemical industry—organic chemical industry—is necessary and, as Dr. Rose inquires, "Does this industry not deserve a home here?" The booklet in question deserves a place in many a library.

ARTIFICIAL STOCK FOODS

IN the *South African Journal of Industries* for June, Mr. W. Jarvis Palmer discusses at some length artificial stock foods and their manufacture. The elements necessary for the sustentation of animal life must contain crude protein or nitrogenous compounds which are the muscle builders, the flesh formers, and the milk producers. Heat energy and fat are derived from the carbohydrates, which consist of sugar and starch, and bear no nitrogen. Fat in such foods also produce fat and heat, while the ash or mineral matter builds up bone in the animal and has an effect upon the digestive system. Crude fiber is in the indigestible element in a foodstuff and serves somewhat as a filler.

The artificial stock foods are usually low in crude fiber and furnish a large amount of digestible matter in concentrated form. In many localities the available food stuff is apt to be low in crude protein, and the value of the artificial food is frequently estimated upon the percentage of this material present. Skim milk and whey are frequently obtainable, the former being rich in casein, which is a nitrogenous compound, and in sugar and ash, while whey, a by-product of cheese making, is principally milk sugar. It is well known that molasses is a valuable carbonaceous food which can be fed in quantities of two to three pounds per day and is useful in making attractive various crude fibers upon which it may be sprinkled.

In South Africa various types of cake, which is a by-product of the oil industry, are used. This includes soya bean, cocoanut, ground or monkey nut, and the cake from sesame, the oil of which is used for soap making and the preparation of edible oils and fat. Fish meal, meat and blood meals, bone meal, and cotton seed products are used there as here. Brewers' grains and the by-products of mills are also highly valued, not to mention ensilage.

In this connection it may be noted that whenever grain is exported as such we send out of our country a quantity of material derived from the mill as a by-product in the grinding of flour and for which there is no adequate substitute as a stock food and a scarcity of which is sure to react eventually upon the price of producing our meat.

COAL TAR SOLVENTS

SO MUCH has been heard concerning the importance of coal tar itself as a starting point in the manufacture of synthetic colors that we may be inclined to consider too lightly the valuable solvents which are recovered in the distillate when coal is destructively distilled. These solvents include benzol, toluol, xylol, and various naphthas. Xylol is quite similar to toluol in its properties and may not be separated as such excepting for a small quantity which finds application in the biological sciences. Coal tar solvents are stronger and usually act more quickly than petroleum solvents and, while inflammable, are far less expensive than such material as carbon tetrachloride. Further, their recovery for reuse is comparatively simple, and these solvents are not subject to the breakdown which accompanies the redistillation of some of the other materials in the presence of moisture, which they are certain to contain after use.

Benzol has a boiling point of about 80°C. while toluol boils at 110. These solvents are being widely used in the extraction of vegetable oils which remain in the press cake after the application of great pressures. It is now possible to remove all traces of the solvent from both the oil and the seed meal, so that the process is applicable to various grades of oil and meal to be used for food purposes, and an increased yield of from 6 to 8 per cent over pressing only is obtained.

In obtaining grease from bones in a process of producing glue and fertilizer, and in treating bones prior to the manufacture of bones or other articles from bone, a special benzol is used being one that has a boiling point such that 90 per cent of the liquid comes over at 100°C. and 100 per cent over at a temperature not above 120°. This is known as 90 per cent benzol.

This same grade of benzol is also used as a solvent for the grease to be found in garbage, and both benzol and toluol are finding their way into the naval stores industry where they are used to recover rosin from stumps and dross.

The 90 per cent benzol, above mentioned, is also being used in the dry cleaning industry, replacing gasoline to a considerable extent, due in part to the difficulty of obtaining a gasoline of sufficiently uniform composition to make it dependable in the dry cleaning establishment.

In the recovery of these solvents simple distillation is ordinarily employed because the materials have a definite boiling point which is low, so that they may be distilled by live steam and separated from water by gravity. They are often cleansed by centrifugal methods.

TRANSFORMING AMMUNITION PLANTS TO THE NEEDS OF PEACE

THIS is a subject of much interest. A report of progress appears in the September issue of *Chemical Age*. It will be realized that the adaptation of the many large special plants erected for war purposes to the somewhat different needs of peace involves a great deal of careful planning and high grade engineering. Several of the ready made cities in industrial centers have been sold to corporations organized for the purpose of creating industrial centers.

One town has been transformed from a practically deserted place, immediately after the signing of the armistice, into a prosperous town of more than 7,000 and is expected soon to overtake its wartime size and activity. Already industries having a total capital of over $17,000,000 have been located at this point and they comprise a sufficient variety to indicate a large degree of stability. On a wartime basis the town produced smokeless powder and the city was built to order to accommodate a population of 35,000. The following industries have found a home at this point: Artificial silk, paper pulp from cotton linters, optical lenses, china ware, high tension

insulation, paper, silk hosiery, hardware, bottling machines, a variety of textile concerns, trunk and bag manufacturers, and producers of different sorts of machines and machine tools.

SOAP AND FRESH EGGS

CHEMISTS in the Department of Chemistry at the Oklahoma Agricultural-Mechanical College at Stillwater have made an intensive study of the subject of egg preservation, particularly by covering the shells with a thin film of aluminum soap. The work is described in the August number of the *Journal of Industrial and Engineering Chemistry*. The report includes a useful bibliography on the subject of egg preservation, a subject which is important in view of the annual spoilage which involves as high as 25 per cent of the eggs handled by dealers. It seems that but a small number of methods have so far been employed in the effort to preserve eggs, and little actual research has been put upon the problem. Most of the work has gone forward in France, Germany, and this country. Some of the earliest methods involved burying or packing eggs in nearly any air-tight substance, some of the simpler being sawdust, oats, and salt. More recently liquids such as cottonseed oil have been employed, and the use of sodium silicate or water glass has become rather common practice. The authors of the new method find various imperfections in the methods thus far practised to exclude air from the egg and recommend aluminum soap for further experiment.

The substance which they employ can be prepared from a soap solution to which a solution of some salt of aluminum, for example, alum, is to be added. Chemically speaking the precipitate which results is a soap; it is not soluble in water, but is easily dissolved in gasoline. In such a solution it is a simple matter to coat the egg with a thin film which has no effect upon the contents of the egg, being both odorless and tasteless. However the solvent gasoline has been found to leave a slight taste which is imparted to the contents, and the problem became how to apply the soap without this objectionable feature. The authors found that the eggs could be protected by the use of dilute sulphuric acid before applying the soap. The effect is to form a thin coating of calcium sulphate in the pores of the egg shells. The eggs immersed in the dilute acid effervesce for about ten seconds after which they may be dipped, without drying, into the aluminum soap solution and placed upon a rack to dry. The extra cost involved is of no consequence and the contents of the egg are preserved without any foreign taste.

Recognizing that this double treatment might stand in the way of the adoption of the method the authors continued their research and concluded that, inasmuch as gasoline is largely composed of pentane which is itself tasteless and odorless, this material might be substituted for gasoline. Fortunately, Dr. Roger Adams of the University of Illinois has devised an inexpensive process for making pentane, and this would appear to solve the problem of producing a solution of aluminum soap which can be applied to eggs at low cost and with satisfaction so far as keeping qualities are concerned.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

ROTO-PISTON VACUUM AND PRESSURE PUMPS

IN these pumps the motions are produced by two cylinders, one, the "roto-piston," being enclosed in the other and touching it at only one point as they are mounted on different axes (Fig. 1). The inner is revolved at the same angular speed as the outer by cranks connecting the two cylinder heads. The throw of the cranks is such as to allow the roto-piston pump to maintain contact with the outer case in an apparently eccentric motion which is, nevertheless, completely balanced. The crescent-shaped space between the cylinders is sealed at its ends by the contact of the cylinders and at any point by a vane which slides in the roto-piston and maintains contact with the outer cylinder.

As the crescent chamber remains fixed in revolution the cylinders roll past it and the vane move through with them, displacing the space as positively as in a reciprocating pump although the motion is rotary and continuous. It has a sliding area of a little over 1 in. on the outer case. The main shaft remains stationary during revolution. There are no valves and the pump is air cooled. The pumps are made in both pressure and vacuum types.—*Iron Age*, Vol. 106, No. 7, Aug. 12, 1920, p. 393.

PUMPS FOR CORROSIVE LIQUIDS

THE question of pumps for corrosive liquids is of particular though not exclusive interest to the chemical industry. Various materials have been tried and while satisfactory for some purposes failed under other conditions. Thus, ferrosilicon resists some acids but not hydrochloric acid, and is unsuitable for processes where contamination with iron must be avoided. Lead and regulus metal cannot be used for solutions containing metallic salts. Ebonite will not withstand hot liquids and is attacked by some chemicals.

It would appear that the substance which is most generally suitable for resisting the action of corrosive liquids is some kind of silicious ceramic material as this can be obtained in forms entirely insoluble in almost any liquid. On the other hand, however, the usual type of ceramic materials is difficult to shape and has somewhat unsatisfactory mechanical properties.

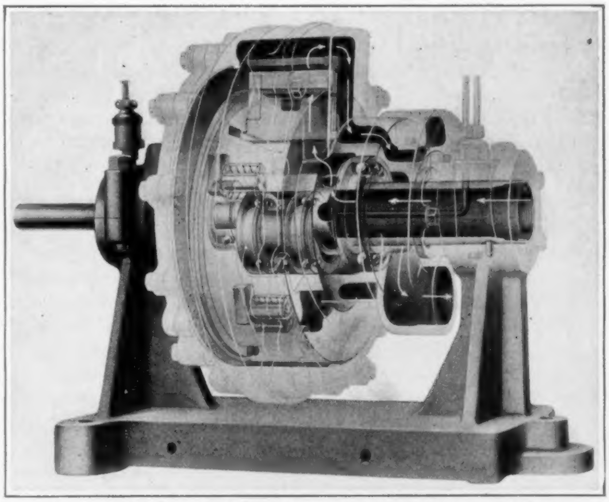


FIG. 1. ROTO-PISTON VACUUM AND PRESSURE PUMP

During the war, however, a new ware was developed under the necessity of finding some substance suitable for apparatus for condensation of large quantities of acid gas. Like silica ware, it can be plunged when red hot into cold water without cracking and has also good heat conductivity. This material

was known as ceratherm. Since the war a modified form of this material was adopted by Guthrie & Co. of Accrington, England, in the manufacture of rare acid-proof pumps. This modified ceratherm material can be manufactured to accurate dimensions with greater ease than the original material.

The design of ceratherm pumps will be understood from Fig. 2. The acid-proof material forming the body of the pump is very thick and strong and is cemented into an iron casing. It is so arranged that it is only subjected by the bolts to crushing stress. The gland through which the plunger passes is usually on the suction side, so that it is relieved from pressure and a stuffing box is packed with a small quantity of wool usually soaked in paraffin wax.

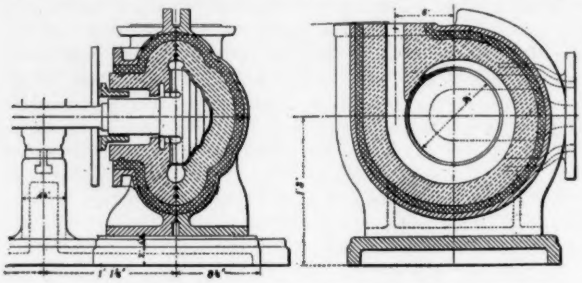


FIG. 2. CERATHERM PUMPS FOR CORROSIVE LIQUIDS

The pumps are built mainly in small sizes to lift, say, from 20 to 100 gallons per minute against a head up to 120 pounds, although pumps have been built for a head of 300 pounds and larger sizes have been made.—*Engineering*, Vol. 110, No. 2851, Aug. 20, 1920, pp. 253-254.

22,000-R. P. M. SINGLE-STAGE TURBO-BLOWER

In 1916 the Westinghouse Machine Company built a small blower designed to run at 43,000 r.p.m. which actually ran at speeds as high as 60,000 r.p.m. In one of the tests the rotor of this blower was damaged, and there is no information available whether it was ever actually placed on the market.

It has proved, however, that blowers running at these terrific speeds are fully practicable.

In this connection the unit recently built by the Rateau, Battu, Smoot Co. of New York City and described in *Power* is of particular interest. The unit was built for a South American mining concern and before shipment was operated at 26,000 r.p.m. for test purposes, but is intended for normal operation at 22,000 r.p.m. It is a single-stage turbo-blower which when operating at its normal speed will compress 3000 cu. ft. of free air per min. to 15 lb. per sq. in. Fig. 3 shows the complete unit assembly, with the turbine at the left.

In the turbine the rotor has three wheels which are machined as an integral part of the shaft which is made of nickel-chrome-magnesium steel, heat-treated, forging, the radial blades being machined as an integral part of the shaft. Fig. 4 shows the rotor removed from the bearing and resting on the lower half of the casing. The 6-in. rule standing vertically on the right-hand end of the casing gives an idea of the size of the rotor which weighs only 138 lb., of which 100 lb. is the turbine rotor and only 38 lb. in the blower rotor.

The rotor had to be made to a single piece in order to give it the maximum rigidity. It is so designed that at all points the stresses are far below the elastic limit of the metal. In machinery running at the high speeds employed in this case (at 26,000 r.p.m. the top speed of the blower rotor is 1,400 ft. per sec., or greater than the velocity of sound) centrifugal forces become of extreme importance.

Fig. 5 gives some data as to the normal performance of the turbine and blower as shown by the elaborate tests made before shipment. An interesting feature of the operation is that at full speed and over the machine operated without the slightest vibration. The results of these tests also show that two machines of this type working in series can be made

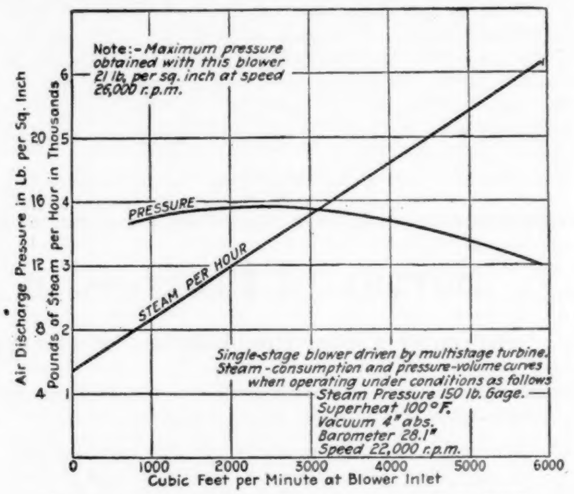


FIG. 5. PERFORMANCE CURVES OF TURBO-BLOWER

to compres air to 100 lb. pressure in small units, and three machines in series would give a compression as high or higher than 100 lb. per large size machine.—*Power*, Vol. 32, No. 9, Aug. 31, 1920, pp. 327-328.

LONG-TIME TESTS OF PORTLAND CEMENT, HYDRAULIC LIME AND VOLCANIC ASHES

Data of two series of tests covering a period of more than 20 years. Some of the cements used in the tests of the first

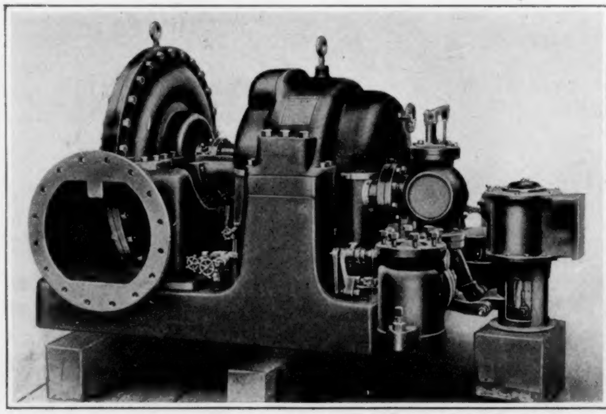


FIG. 3. A 22,000 R.P.M. SINGLE-STAGE TURBO-BLOWER

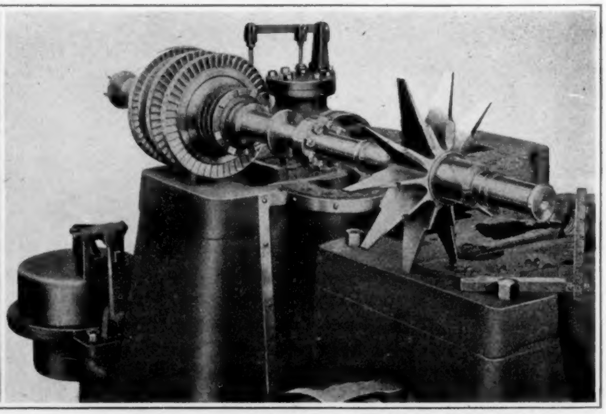


FIG. 4. THE ROTOR REMOVED FROM THE BEARING

series were manufactured by the old process of burning in so-called bottled kilns, while those in the second series were produced in modern rotary kilns. Another series of tests is proposed to be extended over 100 years.

The following are some of the conclusions arrived at:

In sea water neat cement briquettes attained maximum strength in the course of less than a year, after which they rapidly declined, in some cases completely losing their tensile strength in four or five years. The author ascribes this peculiarity to excessive crystallization which makes the structure highly brittle. While losing their tensile strength almost entirely these briquettes retain their form and also show considerable amounts of compressive strength, which latter, in fact, possibly even increases, while the tensile strength decreases.

Cement sand mortar mixtures in the proportion of one part of the former to two parts of the latter in air and sea water show progressive increase of strength with age, the air curves running much higher than sea water ones. The mean results apparently follow more or less closely hyperbolic curves (for which equations are given in the original paper) which would place the eventually attainable tensile strength of such mortar in air and sea water at 85 and 50 kg. per sq. cm. (1,209 and 711 lb. per sq. in.), respectively.

Tests were also made to determine the influence of the kind of sand used for mortars and it was found that while standard and coarse sands produced practically equal strength, fine sand was found to be decidedly inferior in air, fresh water and sea water both in tension and in compression.

As regards the strength of mortars in sea water, it was found that the lower the proportion of sand in the mortar the stronger the latter will be.

The results have, however, also suggested the possibility that in mortars to be used in sea water an excess of cement is to be avoided as much as a deficiency. A proportion richer than $1 + 1$ is too costly and one lower than $1 + 3$ may have voids; the proportion of $1 + 2$, on the other hand, has little more cement than is sufficient to fill up all the interstices in the sand.

Tests on the effect of curing in fresh water on the strength of mortars kept in sea water have not indicated any definite and material improvement due to curing.

An interesting series of tests were made on the use of volcanic ashes in cements, the ashes used being of Japanese origin exclusively. In air tests it was found that the greater the amount of ashes used the lower the strength of the briquettes and none of the ash-content mortars had a strength equal to that of the straight cement ones. On the other hand, in sea water tests the superiority was decidedly on the side of the ash-cement mortars which are, however, weaker than straight cement mortars in compression.

The action of volcanic ashes when used in a cement mortar appears to be twofold, viz., mechanical and chemical. Mechanically, the ashes increase the density of the mixes making the latter more or less impermeable to sea water; chemically, the combination of silica with free lime in cement, which makes the latter unassailable by the sulphates contained in sea water, seems to be the most important action. The activity of silica contained in ashes naturally depends on the state in which it is present; and while there is no doubt that the soluble portion is the most active agent, the total amount of silica should also be taken into consideration. Thus, the Otaru ashes which, according to the analysis contain the least amount of soluble silica of the three, but the largest amount of the insoluble one (on an average of 61 per cent in the Otaru ashes, 47 per cent in the Yoichi, 34 per cent in the Goto) produced higher strength than either of the other two ashes. That a portion of insoluble silica enters into combination to form soluble compounds in course of time is shown by the several analyses made of (Otaru) ash-cement mortar block kept in sea water, the results of which are given in the following table:

	Silica (total 100)	
Time of analysis	Soluble	Insoluble
Before induration	43.75	56.27
2 mos.	46.28	53.72
7 "	47.29	52.71
14 "	50.08	49.92
38 "	53.95	46.05

The value of volcanic ashes, as an ingredient in a cement mortar is possible of direct determination by testing the combining power of the ashes with lime.—By I. Hiroi, *Journal of the College of Engineering, Tokyo Imperial University*, Vol. 10, No. 7, 1920, pp. 155-172.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

THE ELECTRICAL INDUSTRY IN RUSSIA DURING THE PAST FIVE YEARS

DURING the period immediately preceding the World War the electrical industry in Russia made considerable progress. However, it never attained an independent position but was controlled and led by the large German concerns. The latter either had their own factories or were otherwise adequately represented. The factories were unable to meet the demand, and much of indispensable machinery and supplies were imported from Germany. The competition of other countries was ineffective, even when non-German financial interests acquired concessions for building electric plants or railroads, they were compelled to have German firms participate in the construction; hence the total non-German import of electrical machinery and supplies into Russia was comparatively insignificant.

When the war broke out all business relations with Germany were naturally severed. The Russian firms then sent representatives to all countries in order to secure substitute shipments. At the beginning these were not difficult to obtain; soon, however, the available stocks were exhausted. Additional trouble was caused by the wide adoption in Russia of the standards of the Society of German Engineers, standards different from those of other countries. Sweden and Denmark being Russia's nearest neighbors, were confronted by the heaviest demand; they inaugurated the business of transporting goods from the enemy's country, via neutral States, into Russia so that during the actual period of the war German material was obtainable in Russia in largest quantities. However, as Germany began to put up high custom duties and to substitute iron for copper, the Scandinavian countries started up a number of new enterprises and enlarged their old plants. With the exception of a few known Swedish and Danish concerns, like the Allmänna Svenska, for example, these concerns were manufacturing a poor grade of goods.

Thus, Sweden, Denmark and also Holland could not control the Russian electrical market. Japan could make no headway due to inferiority of her material and had concentrated her efforts on the delivery of incandescent lamps (about 25 per cent of the total import of Russia) which proved quite satis-

factory. Even the change in 1917 of the Russian standards which, it was thought, would facilitate the sale of Japanese electrical equipment, did not increase their imports into Russia. Of the other countries, France contributed instruments of precision and special machines, while Switzerland sold meters and some machinery, especially turbines which, in some instances, took two years to deliver.

It was soon realized that the United States would become the only real source of electrical supplies. Consequently, the Russian A. E. G. turned to the General Electric Company of Schenectady, the Russian Siemens-Schuckert Works to the Siemens Brothers and the Dynamo Company to the Westinghouse Company. As it was assumed that the war would be of short duration and as it was thought possible to re-establish later the old relation with Germany, the transactions with the new English and American connections were considered of temporary nature. The first shipments of any importance from England and America arrived at the end of 1916; a very lively demand then followed resulting in orders which at the end of 1917 amounted to about 25-30 million rubles. On account of the revolution only a part of these orders was filled. Up to the time of the blockade only 20-30 per cent of the machinery ordered may have reached the interior of Russia and probably a still smaller percentage was put in operation. However, the English and American material proved of a superior quality, the machines were of adequate capacities and the meters and the various apparatus of substantial construction. Consequently they were considerably more expensive than the German products. It must be also observed that only the largest firms made any important shipments to Russia so that no very intimate connection was established between the Russian and the foreign business houses.

In spite of very unfavorable conditions Russia also made a great effort to enlarge her own plants and build new ones. In order to avoid possible capture by the Germans, one of the largest plants, the A. E. G. (formerly union) of Riga was transferred to Kharkov; this involved the moving of thousands of tons of raw material and machinery and of thousands of employes. A new large plant was erected at Kharkov which compares favorably with any similar plant abroad. It is equipped for the manufacture of the largest machinery. Situated in this important industrial center, these works will probably become of greatest value in the future.

The factories of the Volta Company at Reval were also removed. The Siemens and Halske and the Siemens-Schuckert Works enlarged their plants and built new plants; the Dynamo Company did likewise. The Allmänna Svenska also built a factory in Russia. A number of smaller ones that sprung up did not amount to much probably on account of lack of material and of technical help. A number of lamp factories were also built; of these only two reached an output of 0.5 million lamps a year. These were all independent firms and could not stand any formidable competition.

It might be of interest to know something about the situation of the electro-technical industry under the Soviet regime. The electrical concerns, as all others, are nationalized. An Electro-technical section is established in Moscow as part of the Higher Council. Its manager is the former head of the Electro-technical section of the War Industry Committee. The former companies are acting as sub-sections, and their board of directors are only partly composed of their old directors and, to a larger extent, of directors appointed by officials and the employes. The boards of directors are considered as group leaders. The budget of each group is planned for some months ahead by their leaders and then submitted to and approved by the Electro-technical Section of the Higher Council. The firms operate at the expense of the State Bank which places enormous sums at their disposal. There is a similar Electro-technical Section in Petrograd; besides there is the Higher Electro-technical Council which deals with matters of a more general nature, as with drawing up of projects, questions of standardization, etc. Fortunately, there have been no victims of the revolution among the leading personalities in the electrical industry. They have chosen to remain on their posts in spite of hunger and all kinds of hardships. Thus, they have saved the organization which is important for a coming reconstruction.

It is needless to point out that the Soviet organization has no favorable influence upon the working efficiency of the plants, yet one important favorable result of the elimination of competition must be mentioned. As it is well known, the Russian engineers and technical manager were always inclined to pay a good deal more of attention to theoretical points than practically necessary. They wanted the seller to deliver not the accepted standard of machinery and efficient apparatus, but they expected him to adapt himself completely to the buyer's taste, very often to the detriment of the latter. By being too compliant in this regard the former German firms in Russia quite spoiled the market. This has now been remedied. Standard types only are hereafter to be constructed, and no exceptions to be allowed. It is true that the English and American manufacturers had already during the war time influenced the Russian market in that direction.

As to the future it may be said with certainty that all electrical concerns of the allied as well as of the former enemy countries, will hardly be able to meet the Russian demand for electric machinery and supplies during the coming ten years. Remembering further the shortage in raw material all over the world, the flooding of the Russian market by any one party is hardly to be feared. It should be further remembered that the German language is extensively spread in Russia while the English has been known only since the war time. As there will be no time to waste when the work begins the Germans ought to be in the most favorable position as they will be able to understand and make themselves understood by the Russian officals.—N. O. Lifschitz. *Elektrotechnische Zeitschrift*, May 20, 1920, pp. 393-95.

FLYING FERRIES

AN interesting application of electric motors is described under the above heading in *Engineering Progress*, April, 1920.

The Oste, a left bank tributary to the Elbe, carries a lively ship traffic, even of seagoing vessels. At the same time, however, a busy land traffic exists from bank to bank. The old ferry proved quite inadequate as it could not be used in stormy weather and at flood tide. On the other hand the scheme to replace the old ferry by a permanent bridge which could be opened so as to allow the vessels to pass had to be abandoned on account of the enormous expense involved. The Maschinenfabrik Augsburg Nürnberg met these difficulties by designing a flying ferry, the construction of which is very little known, but which may be very valuable to meet similar conditions elsewhere. The ferry was designed to accommodate two horse trolleys and about 25 passengers. The span of the bridge had to be such that there was at least a clear space of 100 feet of water way between the bridge pillars and it had also to be 70 feet high in order to allow a full rigged sea-going vessel to pass underneath at the highest flood tide.

The gage of the track of the ferry trolley is 30 feet, the wheel base of the trolley 26 feet, the useful space of the ferry platform 46 x 11½ feet. The structural steel frame work from which the ferry platform is suspended is only 26 feet wide and therefore the two ends of the platform are built overhanging on both sides. The platform and the trolley on the bridge are connected together by rigid structural steel girders in order to prevent a swaying of the platform under a strong breeze. The trolley on the bridge is provided with four wheels contained in a strong plate girder frame. The wheels are driven by two electric motors which receive a supply of current from a trolley wire of silicon bronze. The power is transmitted to the driving wheels by means of a worm gear and pinion. Both motors are coupled together by means of

bevel gears mounted on a common shaft, in order to insure uniform working. The motors are controlled by means of a series-parallel controller mounted on the platform. The ends of the track on the bridge runaway are bent upward. A short distance from the ends of the track two limit switches for interrupting the current have been provided, these limit switches being operated by means of control levers mounted upon the trolley. Two compressed air buffers mounted upon brackets to the support of the rails prevent a runaway or the trolley overrunning the track.

The current necessary to operate the flying ferry is generated in a small power station by means of two petrol motors of 10 hp. each. This output is sufficient for moving the fully loaded platform at a speed of 1.6 feet per second. The time required for one trip (260 feet) is roughly three minutes. The weight of the ferry, including trolley and driving mechanism, is 34 tons. The total cost of the ferry amounts to 180,000 marks as against 420,000 marks which a suitable draw bridge to meet the same conditions would have cost.

PORCELAIN INSULATORS

AN interesting article on "Porcelain Insulators" appears in *Revue Générale de l'Electricite* for May 22, 1920.

This article is a report to the French "Union of Electric Concerns," submitted by the chairman of a sub-committee, Prof. O. Boudouard, and gives the results of his original chemical researches on porcelain.

A number of insulators of modern manufacture were submitted to Professor Boudouard by various French operating companies. With each sample information was furnished by the interested company with regard to origin of the insulator, their methods of using it as well as their own observations on the same. All this data is carefully tabulated by the author in Table I. In Table II a detailed chemical analysis is given, the samples being grouped according to their origin, i.e., German manufacture, American manufacture and French manufacture, while in Table III all the samples are arranged in accordance with their chemical composition, regardless of make. The fracture surfaces of all the analyzed samples were carefully examined and the results tabulated.

Another table contains a summary of all the observations made by the various electric operating companies in regard to the causes of accidents resulting in breakage of insulators and in regard to the meteorological conditions of the various localities where they were used.

Conclusions: An examination of the analytical results discloses a considerable variation in the chemical composition of the various kinds of porcelain. For instance, the author draws our attention to the fact established by his tables, that SiO_2 varies from 63.31 per cent to 74.49 per cent or Al_2O_3 varies from 20.45 per cent to 29.75 per cent. He also points out that the chemical composition of porcelain produced in the same factory also varies to a marked degree. We quote the following discussions of molecular formulas:

"Watts indicated the following molecular formula as being the most suitable for the manufacture of electrotechnical porcelain, viz.:

$$0.25\ RO \times Al_2O_3 \times 4\ SiO_2$$
$$\text{or } RO \times 4\ Al_2O_3 \times 16\ SiO_2$$

If the porcelains analyzed are grouped according to their molecular formulas, three series of products are obtained, each corresponding to one of the following formulas:

$$RO \times 3.5\ Al_2O_3 \times 15.7\ SiO_2\ \frac{SiO_2}{Al_2O_3} = 4.5$$

$$RO \times 3.83\ Al_2O_3 \times 9.62\ SiO_2\ \frac{SiO_2}{Al_2O_3} = 5.5$$

$$RO \left\{ \begin{matrix} CaO \\ (K - Na)_2O \end{matrix} \right\} \times 2.47\ Al_2O_3 \times 9.62\ SiO_2\ \frac{SiO_2}{Al_2O_3} = 3.89$$

"I have composed synthetic porcelain in the laboratory in accordance with those compositions in order to study their comparative structure. . . . It should be stated here that some of the German porcelains, the American porcelains and many of the French porcelains belong exclusively to the first groups, thus approaching the Watts formula."

Referring to the table giving the service records (as furnished by the power companies) of the samples analyzed, Professor Boudouard points out that those that failed are either very rich in silicon or in calcium. They also showed mechanical defects in molding.

"Hence it is safe to say that the chemical composition and the molding of the porcelain constitute important factors which should be considered when the service quality of the insulator is to be estimated."

50,000 KW. THREE-PHASE TURBO-GENERATOR

A UNIT of the above size has been constructed by the Allgemeine Elektricitats Gesellschaft of Berlin and erected at the Rhenisch-Westphalian Power Station, Essen, Germany.

Current is generated at a pressure of 7,000 volts when running at a speed of 1,000 r.p.m., the exciter being furnished with current at 220 volts. Steam is supplied at a pressure of 170 lbs. superheated to 325°C. (617°F.). The cooling water for the condenser is 81°F. The whole of the 75,000 hp. required is produced in a single turbine chamber which weighs 201 tons, with a rotor weighing 49 tons, thus making a total of 250 tons for the complete turbine. The weight of the dynamo is 225 tons of which the rotor accounts for 106 tons. Special trucks were constructed to convey the machinery from Berlin to Essen. The turbine is equipped with two surface condensers each having 32,300 sq. ft. of cooling surface and weighing 100 tons. They are connected through two 98½-in. dia. exhaust pipes. The turbine rotor varies between 11 ft. 1¾ in. and 12 ft. 5⅝ in. in diam. while the dynamo rotor is 7 ft. 2⅝ in. in diam., corresponding to a circumferential velocity of 590.56, 721.80 and 377.30 ft. per second respectively. The latter rotor is 29 ft. 6 in. long and consists of a number of plates mounted on the shaft. Special precautions were taken to ensure perfect balancing of the rotors which were tested in the workshops up to a speed of 1,500 r.p.m. and the separate plates up to 2,000 and 2,400 r.p.m. The main bearings of the turbine shaft are 23⅝ in. in diam.., giving a normal circumferential velocity of the latter of 105 ft. per second. A speed of 154 ft. per second was reached during special centrifugal tests which were conducted at great expense to ascertain whether damage would result to the bearings.

The plant was built during the war, and great difficulties were caused through lack of standard materials, such as nickel, copper and tin. Substitutes were used, but the machinery has, nevertheless, given complete satisfaction during the time it has been at work.—Gustav W. Meyer, *Technische Rundschau*, April 15, 1920. *Technical Review*, September 14, 1920.

POWER FACTOR

POWER factor has been the subject of considerable discussion in recent years. In recognition of the importance of this subject, the Standards Committee of the American Institute of Electrical Engineers and the Technical Section of the National Electric Light Association have recently formed a "Joint Committee on Determination of Power Factor in Polyphase Circuits" (see *Journal of the A.I.E.E.*, June, 1920). It is pointed out that no agreement has yet been reached upon a definition of the term (power factor) as applied to polyphase circuits, nor even upon the underlying purpose which a definition should serve to express. With approximately balanced polyphase loads, such as we had up to recent years, no refinement in the definition of power factor is needed. At present however there is an ever increasing number of important industrial power loads, which produce unbalanced conditions. The increasing commercial importance of this character of load and the growing tendency toward such refinements in power contracts and rates as will reflect accurately the various elements entering into cost of service, have combined to render

this power factor problem a matter of immediate and urgent practical importance.

In its report the committee has arrived at two definitions covering two different forms of power factor. The definitions are as follows:

Definition 1—"Power factor in a polyphase circuit is the ratio of the total watts to the (arithmetical) sum of the volt-amperes in the several phases, each measured to a non-inductive neutral point. This definition may be otherwise expressed as the weighted mean of the individual power factor in the phases (weighted according to the volt-amperes in each phase").

Definition 2—"Power factor in a polyphase circuit is the ratio of the total watts to the vector sum of the volt-amperes in the several phases."

These two definitions are further discussed from the point of view of the supply company ("Polphase Power Factor" by H. L. Willan.

Definition 1 being mathematically accurate should be adapted to single phase or to balanced polyphase circuits, while definition 2 has a broad field of usefulness when applied to unbalanced circuits. The central station industry today is compelled to take on single-phase loads of considerable magnitude. These loads consist of welders of very poor power factor (20 to 40 per cent), single phase arc furnaces of poor power factor (35 to 70 per cent), together with inductive and non-inductive loads of other kinds. The results of these unbalanced loads are reduced effective capacity of three-phase circuits, and increased heating in cables, and if the out-of-balance becomes of sufficient magnitude generator troubles will result.

Increased costs of supply result therefrom. This added cost must either be proportional over all consumers alike, or some means must be found to penalize the consumers causing the added burden. This means would be provided by a power factor clause. If, however, a strictly technical definition is adopted (definition 2) it would take no account of the effect of unbalanced currents yielding as it does a higher power factor than that obtained by the proposed commercial definition 1.

Definition 1 takes into account the maximum wattage obtainable based on existing currents and voltages, and the ratio of this quantity to the actual watts measured is the power factor. This definition, the author believes, should be standardized for commercial work. Furthermore, he believes we must determine a suitable, reliable, inexpensive and uniform method of measuring power factor. To date neither definitions nor methods are standard with us and there is a real need for both.

The mutual relations of a number of possible definitions of power factor and their relative merits for specific types of circuits are discussed by Francis B. Silsbee, Associate Physicist, U. S. Bureau of Standards in a paper entitled "Power Factor in Polyphase Systems." Power factor has two distinct applications, for economic and technical purposes respectively and the selection of the single property which any one definition of power factor can determine must be considered from two distinct points of view. The economic importance arises from the fact that it is more expensive to supply a given power to an actual load in which the currents are not in phase with the voltages or in which the currents in the several phases are not equal in magnitude, than it is to supply a standard load in which some or all of these adverse conditions are absent. In this connection two items of cost must be distinguished: (1) The fixed charges on the additional generator and line capacity required to supply the actual low power factor load and (2) the cost of the additional power lost in the generating circuits. The ratio of the actual power to the power which might be supplied to a standard load either by the same generator capacity or with the same power loss may be taken as the logical economic definition of power factor.

There are three distinct types of standard load: (A) a balanced load in which both the currents and the voltages are symmetrical and in phase; (B) a load in which the currents have the same magnitude as in the actual load but in which the current system as a whole has been shifted in phase with respect to the voltage system, so as to make the total power a maximum; and (C) a load in which each current has the same magnitude as in the actual load that has been individually shifted into phase with its corresponding voltage. For a standard load of type (A) and a symmetrical polyphase generator the most logical power factor is the ratio of the watts to the effective volt amperes. For a standard load of type (B) the "vector power factor" definition (Definition 2 of the special joint committee) and for a standard load of type (C) the "arithmetical power factor" (Definition 1) are most logical.

For technical purposes it is highly desirable to separate the effects of phase displacement, unbalanced and wave form, since the causes and remedies for each are quite distinct. This can readily be accomplished be defining one or more additional quantities so that one quantity (such as "vector power factor") indicates the phase displacement as distinct from unbalance; and a second quantity (such as balance factor) shows the symmetry of the loading as distinct from any general phase shift. The first quantity thus shows the extent to which conditions might be improved by the installation of synchronous condensers, while the second indicates the possible gain from phase converters or by rearrangement of the load.

SYSTEMS OF ELECTRIC TRACTION ON MAIN LINES

F. NIETHAMMER gives in *Elektrotechnik und Maschinenbau* his observations of the various Swiss railways. As a result of his inspection he considers the following systems to be suitable for general use: (1) Polyphase current with a trolley voltage of 3,000 to 6,000 and a periodicity of 50; this requires gearing in the ratio of 1 to 3 between the motor and the driving axle; the double trolley wire is perhaps an objection; squirrel-cage motors with variable poles are suitable. This system requires substations along the track with transformers. (2) The single-phase system with phase-splitting devices. Single-phase current at 15,000 volts with a periodicity of 50 is conveyed to the train which carries a rotating phase-splitter delivering current to a synchronous polyphase motors, preferably of the squirrel-cage type, combined with variable poles and gearing; single-phase transformers are distributed along the line. (3) High-tension direct current at 3,000 to 5,000 volts, supplied from rotary converters along the line, or from motor-generators. This is probably more expensive than the other systems both in initial cost and in working expenses; however, in this case it is easier to allow for short overdrafts of current, and accumulators could be used so that the same generators could be used to supply the traction load as well as the general outside load, whereas on (1) and (2) separate generators would be needed for the railway, owing to the instability of the load and the impossibility of dealing with sudden rushes of current. There is no reasonable possibility of converting the ordinary polyphase current of 50 cycles into similar current of 16 2/3 cycles; if the polyphase current is to be converted at all, it should be changed into direct current, and it is quite likely that this will be possible on a large scale in no distant time by means of mercury vapor converters, which are already applied to this purpose on an industrial scale.

On the whole, the eventual tendency will be in the direction of high tension direct current produced by some kind of converting device from high tension polyphase current; there is also the possibility that accumulator traction may to some extent meet the case, and of this there are signs in America where traction of this character seems to be successful in the shape of certain types of motor car; however, this will depend on the adaptability and future developments of the accumulator.—*Elektrotechnik und Maschinenbau*, Vol. 37, pp. 509-12; *Science Abstracts*, Section B, March, 1920, Vol. 23, pp. 157-58.

Progress in Mining and Metallurgy

Abstracts of Papers To Be Read at the New York Meeting of the A.I.M.M.E.

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

POTASH DEPOSITS OF ALSACE

By Hoyt S. Gale

When potash was discovered in Alsace, in 1904, the monopoly of the potash industry held by the owners of the great deposits in north central Germany since 1860 was broken. The new field, although less extensive, was soon recognized as having several important advantages over the older. The Alsatian deposits underlie a large area in exceedingly regular beds, and the salts are, on the average, remarkably rich in potash. The deposits consist of a simple mixture of potassium and sodium chlorides, known as sylvite, with very little other soluble material. This mixture requires only the simplest chemical treatment to purify it into the higher grades of potash salts.

It has seemed a coincidence that the only really large deposits of soluble potash salts that have been developed should have been opened within the domain of a single empire. The return of Alsace to France divides the monopoly and general interest in the details of the Alsatian field and its prospects for the future has increased.

Many excellent descriptions of the geology and the conditions of the Alsatian potash deposits have been published. Most of these are written in either French or German and from the viewpoint of those having a special local interest. The writer visited all the properties accessible during the spring of 1919 and is able to give not only an abstract of what has already been published but some original account of recent developments.

Estimates of the reserve supply of potash in the potash field of Alsace have been frequently quoted; these are based on substantially the same data and course of deduction and are in essential agreement. The average thickness of the whole bed is 3.507 m. The upper bed contains no shale partings and the available measurements give an average thickness of 1.164 m. The cubic content of both beds is figured as 700,980,000 cu. m. potash salts, which at a specific gravity of 2.1 is equivalent to 1,472,058,000 metric tons. The usual assumption of the average potash content for the field at 22 per cent K_2O would give, in round numbers, somewhat more than 300,000,000 tons of pure potash, as the estimated reserve in the ground. This would provide the world's need, at the normal rate of consumption before the war, for about 275 years.

A study of the results of operation shows that the quality of the raw salts produced in mining operations does not run as high as the figures on which the total tonnage estimates are based. Very probably the higher figures are correct, as indicated by the analyses of carefully cut and preserved samples. In ordinary mining operation, however, much dirt is included and the crude material as taken from the mines, including both ordinary and hand-sorted grades, probably does not contain over 18 per cent of potash, K_2O. The accidentally included dirt need not diminish the estimated total resources of the field, but it does affect the practical interpretation to be given to figures quoted as showing the average quality of the deposit as represented by its average output.

The appearance of the potash salts in place is striking. The high walls of sparkling crystalline salts are banded in approximately horizontal stripes of red and white, more or less wavy, giving the impression of a portion of an immense flag. On clean mine faces, the colors are beautifully clear; some of the bands are a deep rusty or brick red; others are delicately pink. There is also much white and gray granular material. The belief that the red and some of the pink salts are directly associated with the richer potash portions of the bed is so generally expressed throughout the field that it must have some foundation in fact although perfectly white or transparent crystals of almost pure potassium chloride have been found. A close examination, though, shows that the coarse crystals, both red and white, are intermixed and it is not usually possible to trace a distinct boundary between them but, in general aspect, the banding is very distinct.—From *Bull.* 715 B, U. S. Geol. Survey.

STEEL CHIMNEYS AND THEIR LININGS IN COPPER SMELTING PLANTS

By A. G. McGregor

Some of the chimneys in the copper smelting plants of the Southwest that have been installed for twenty years show no deterioration, while others show serious deterioration after four years.

A steel stack 20 ft. 7½ in. in diameter by 279 ft. high, used for roaster gases only, in the Calumet & Arizona Mining Co.'s plant at Douglas, Ariz., was lined to the top of the bell with common brick, lime and cement motar being used. Above the bell the stack was lined with building tile. The chimney was put into use the latter part of 1913 but four years later considerable of the tile lining had fallen out of place. Two years later, several holes, a square foot and smaller in area, appeared in the steel shell and soon afterwards the chimney was shut down for repairs. When tile is exposed to the deleterious action of the gases, its thin walls gradually disintegrate and finally fail. Brick is more satisfactory for the walls of flues and dust chambers than tile.

At the same plant a steel chimney 25 ft. 9½ in. in diameter by 305 ft. high lined with hollow building tile, the same as the preceding, has been in use since June, 1913, for blast and reverberatory furnace gases. The lining is still in place and there is no noticeable deterioration of any part of the structure.

At Cananea a steel chimney 19 ft. 9 in. in diameter by 170 ft. high, lined with common brick, was put into service in 1903. It is used for the blast furnaces and so far there is no apparent deterioration.

At the Calumet & Arizona plant at Douglas, a steel chimney 15 ft. diameter by 200 ft. high, unlined since it was erected at the original plant in 1906, serves as the converter-department chimney and apparently is still in as good condition as when new.

At the International Smelting Company's plant, at Miami, an unlined steel stack 15 ft. diameter by 200 ft. high is used for discharging the gases from the converter department. Though in service since May, 1915, except for the period of a strike of six weeks' duration during the rainy season it shows no signs of deterioration.

At Morenci, Ariz., the Detroit Copper Co. put an unlined steel stack, 13 ft. in diameter by 165 ft. high, into operation in September, 1899, to discharge gases from copper blast furnaces and converters. It has been cold during several periods on account of strikes, but at present is in good condition, except the upper 12 ft., where it has commenced to deteriorate since the plant was shut down eight months ago.

At the Copper Queen smelting works in Douglas, an unlined steel chimney 25 ft. in diameter by 260 ft. high was put into service in June, 1904, for blast furnace and converter gases. The chimney has an inside coating of caked flue dust about 2½ in. thick but the steel is its original thickness. The chimney has not been cold since 1906.

At the Old Dominion smelting plant in Globe, an unlined

steel stack 14 ft. in diameter by 200 ft. high has been in use since August, 1904, for blast furnace and converter gases. The plant has been shut down several times, once six weeks during the rainy season, but the stack shows no signs of deterioration.

At the International Smelting Company's plant at Miami, Ariz., a steel chimney 22 ft. in diameter by 300 ft. high is used for reverberatory furnaces gases only. The lining in the bell of the chimney is of common red brick, above the bell common red building tile is used. The tile lining is 4 in. thick. The chimney was put into use in May, 1915; in 1917, the plant was shut down, on account of a strike, for six weeks during the rainy season. About a year afterwards certain sheets had become distorted and investigation showed that the steel sheets above the lining were seriously weakened from corrosion. A temporary repair was made by reinforcing the chimney for 75 ft. of its length with an outer steel shell. Corrosion is continuing, and a new radial brick tile chimney is being built to replace the steel chimney.

A steel chimney at the reverberatory furnace plant of the Cananea Consolidated Copper Co., 12 ft. in diameter by 171 ft. high was put into service in 1902. The lower part of the stack has deteriorated but little.

Based only on the examples cited, the following may be said: Unlined steel chimneys have not given satisfactory service when used for roaster furnaces or reverberatory furnaces but they have given satisfactory service for long periods when used for blast furnace and converter gases.

Building tile has proved unsatisfactory for chimney linings or for the construction of walls for flues and dust chambers where exposed to roaster furnace gases or cool reverberatory furnace gases.

These remarks apply for the ordinary conditions met with in copper smelting plants, where waste heat boilers are used in connection with reverberatory furnaces, and where no particular effort is made to maintain the gases at a high temperature in the flues, dust chambers, stacks, etc.

COKE AND BY-PRODUCTS AS FUELS IN METALS MELTING

By F. W. Speer, Jr.

The by-product coke oven is the most important artificial source of fuels for metals melting. Its products are solid, liquid, and gaseous. The amount of coke and primary by-products obtained per ton of coal varies with the nature of the coal. The following represents the results obtained in many plants:

Metallurgical coke (over ¾ in.)	69 per cent of coal
Domestic coke (½ to ¾ in.)	2 per cent of coal
Breeze (under ½ in.)	4 per cent of coal
Surplus gas, cubic feet per net ton	6600
Gas for heating ovens, cubic feet per net ton	.4400
Tar, gallons per net ton	9
Ammonium sulfate, pounds per net ton	25
Benzol, gallons per net ton	4

All of these products except ammonium sulfate have important fuel value. Part or all of the metallurgical coke may be crushed or screened to furnish additional domestic coke. If producer gas is used, there will be a surplus of 11,000 cu. ft. of coke-oven gas per net ton of coal.

The use of coke in the metallurgical industries has been retarded by the mental attitude of writers who disregard the dependence of coke quality on the conditions of its manufacture. Terms like "by-product coke," "beehive coke," "48-hour coke," and "72-hour coke" are only generally descriptive and tell nothing of the coke quality.

One of the greatest achievements of modern by-product coking has been to bring the most important elements of coke quality largely under the control of the operator, so that it is possible to produce coke conforming closely to certain specifications. The basis for the specifications depends largely on the needs of the customer, who should have a correct understanding of his own requirements. The results obtained with by-product coke in the blast furnace are due, not only to improvements in coke quality, but to a better understanding of the requirements of the blast furnace and improvements in blast furnace equipment and operation. It does not follow, that the coke which will work best in a certain type of blast furnace with a certain ore mixture is the one best suited for metal melting. In the melting of non-ferrous metals, oxidation and loss by volatilization are of prime importance; coke consumption is, to some extent, secondary, what would give the best results in a brass-melting furnace would probably differ from that considered to be the best for either the iron foundry or the blast furnace.

The use of coke-oven tar as a metallurgical fuel has grown steadily during the past few years. Its most important use has been in the manufacture of open-hearth steel, where it has largely replaced or supplemented producer gas or fuel oil.

The modern by-products coke oven is not only adapted to the manufacture of metallurgical coke, but is capable of furnishing coal gas equal to that manufactured in the ordinary gas retort. With properly selected coals, the modern by-product coke plant will produce straight gas having a heating value of 560 B.t.u. per cu. ft. after the removal of benzols. The general advantages of high-grade gaseous fuels for metals melting have been frequently discussed. No preheating, recuperation, or regeneration of the gas is necessary; preheating would be disadvantageous in the case of coke-oven gas, which readily undergoes decomposition when heated. The use of coal gas results in greater ease of regulation, reduced loss of metal, increased speed of heating, and longer life for the furnace. The advantages appear to be greatest in comparison with solid fuels; but there is also some advantage in each respect over oil. All things considered, coke-oven gas is cheaper than any other high-grade artificial gas, and as it is coal gas of low specific gravity, it has a lower cost of distribution per British thermal unit than all other artificial gases whether of low or high grade.—Presented at the Columbus Meeting, Oct. 4-8, 1920.

DETERMINATION OF THE HARDNESS OF BLAST-FURNACE COKE

By Owen R. Rice

It is the purpose of this paper to show what a great hindrance to proper blast-furnace operation is soft coke; that there is no reasonable change in coke hardness that does not show its effect on the furnace.

The best method for determining the hardness of coke is by the use of a combination tumbler-ball mill.

Soft coke is due to a low hydrogen-oxygen ratio in the coal charged; increasing this ratio improves the hardness of the resulting coke.

The shatter test, in one form or another, is now largely employed; it usually consists in dropping 2-in. coke four times upon an iron plate from a 6-ft. elevation, and then screening through certain sizes of mesh, the various sizes thus separated being reported as percentages. Thus is obtained an index to the condition of the coke by the time it reaches the furnace, having undergone the four major stages of handling; viz., cars-to-bins, bins-to-larry, larry-to-skip, skip-to-bells. But the shatter test does not predict the condition of the coke when it reaches the tuyeres. Indeed there is frequent trouble if the shatter test is depended on to determine hard or soft blast-furnace coke.

In following Cochrane's lead, we have used a combination tumbler-ball mill to determine the hardness of the coke fed daily to three of our 500-ton furnaces, the bosh angles of which are 76°, 76°, and 73½°, respectively. Thirty pounds of dry 1-in. coke is tumbled for 1,250 revolutions (at 20 r.p.m.) with eleven 1¼-in. steel balls. The resulting fines are screened out through ½-in. mesh, and the remaining portion is weighed

and reported as per cent of original. This quantity is termed the coke hardness number.

It would be absurd to claim that hard coke alone is the "pain-killer" for all blast-furnace maladies; furnace operation has fluctuated when the coke hardness did not but no reasonable change in coke hardness will fail to show its effect on the furnaces.

The furnacing quality of coke required is its resistance not only to fragmentation but to abrasion; this characteristic is well indicated by the tumbler test. The use of steel balls in the tumbler is advantageous, as in the furnace the coke is in contact with masses of greater density than itself. The introduction of hot CO_2 gas would add both interest and complexity to further investigations.

Coke hardness has a marked effect on blast-furnace "health." The furnace is more immediately sensitive to the kind of hardness that resists wear and tear within the furnace, as shown by the tumbler test, than to the kind of toughness that resists rough handling without the furnace, as shown by the shatter test. The tumbler test is therefore superior for daily control. We recommend its adoption moreover on grounds of simplicity, reduction to a great extent of the personal equation, and the saving of labor.

The shatter test is of value as a matter of record but does not surpass the tumbler test in this respect.

Both tests for coke hardness show reliable coördination with the hydrogen to oxygen ratio of the coal used; the higher this ratio, the harder the coke.

Correspondence

The editor is not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.

NEW LIFTING ELEMENT

To the Editor of the Scientific American Monthly:

Having performed hundreds of experiments during a period of ten years with some two dozen working models of vertical flying machines, including helicopters, I submit the accompanying mechanism which, I believe, embodies an aerodynamic principle never before recognized or stated, and which I have found to yield the largest lift per unit of power consumed, and to lend itself to simple control for attaining any desired rising or falling speed as well as stationary or hovering flight.

I present here only the lifting element as that constitutes the crucial part of the problem. The skeleton diagram illustrates the mechanism and my experimental apparatus as arranged for quantitative measurements.

In the diagram, BB are bicycle wheels with sensitive bearings, mounted in firm supporting brackets and with tires removed.

A rope runs over the rims, from one end of which is suspended the mechanism, M, and from the other end a counterweight, W.

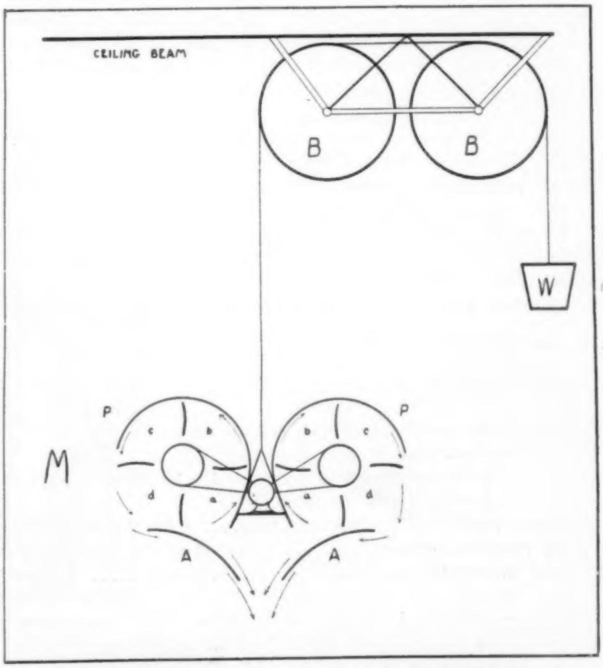
For the counterweight I use a receptacle filled with old type which is convenient for minutely increasing or decreasing the weight. This arrangement allows the mechanism to be operated under all sorts of variable conditions and very accurate measurements to be taken of its performance. I first drop type into the receptacle until the idle mechanism and the counterweight are exactly balanced. I then remove a quantity of type known to be somewhat more than the mechanism can lift and place it in the scale pan. The machine is now set in operation and type removed piece by piece from the scale pan and dropped into the receptacle until the mechanism rises. The weight of type remaining in the pan is the measure of the lift.

The lifting mechanism, M, comprises a pair of 1/8 electric motors mounted end to end upon a platform, their grooved pulley heads abutting with a thin clearance space between, and rotating in opposition. These drive a pair of 4-vane tangential fans as indicated by the arrows. The fan pulleys are placed midway of the axes and the vanes are parted in the middle to give clearance space for the driving belts.

For convenience of analysis I establish the fixed quadrants of reference, a, b, c, d.

Coöperating with the fans are cylindroidal collector or guide planes, PP, conforming, with close clearance, to the peripheries of rotation throughout quadrants c and b, but gradually falling away from the peripheries through quadrant a. These planes are polished on their interiors and are so adjusted as to collect all the dispersed tangential streams generated by quadrant a, with an oblique or glancing blow so as not to retard their velocity, and to turn them back upon themselves and downward through an angle of 180°. The streams from quadrant b are turned downward through an angle of 90°. Those from quadrant c are by nature correctly directed and are allowed to impinge upon the stationary outer air.

In order to utilize the normally useless streams from quadrant d, aeroplanes, AA, are mounted below the fans, and operate in the blasts from quadrant d in precisely the same manner as ordinary aeroplanes in a natural wind or in the



SKELETON DIAGRAM OF THE LIFTING MECHANISM

air streams generated by their motion through the air. By these planes the streams from quadrant d are also turned downward through an agle of 90°.

It is well known that the motive force imparted to a concave receiver by an impinging stream depends upon the turning angle imposed upon the stream by the concave. When the turning angle is 90°, such motive force is one unit for each unit residing in the stream. If the turning angle is 180°, the motive force imparted is two units for each single unit possessed by the stream. It will be seen from this that in relation to quadrant a, the upper cylindroidal plant is virtually an aerodynamic Pelton bucket, and consequently receives a lift from quadrant a, which is double the natural energy of the stream.

We may now analyze the lift by quadrants and express its magnitude in units of energy generated naturally by the fans when running in open air and uninfluenced by the planes:

Quadrant a, 2 units; Quadrant b, 1 unit; Quadrant c, 1 unit; Quadrant d, 1 unit.

Were the quadrants all independent, the sum of their quotas would be a total equal to 5/4 the total natural energy of the fans. Nor would there be anything anomalous in such a result. It is to be noted, however, that the lift of quadrant c is due to reaction directly upon the vane instead of upon the planes as in the case of the other quadrants. Therefore, the lift of this quadrant is communicated to the mechanism through upward pressure at the fan pivots. But the upward impulse given to the stream by the vane of quadrant a produces a downward pressure at the pivots equal to the upward pressure caused by the lift of quadrant c; consequently the lift of quadrant c is at the expense of one of the two units contributed by quadrant a.

Special proposition—The total energy of the fans is converted into net lift, undiminished by any adverse or downward reactions; for, given a tangential fan rotating in a vertical plane in open air, the forces take the form of an infinite number of tangential force lines equally distributed all around the circle of rotation, and an equal and opposite set of tangential reactions about the fan pivots.

The algerbraic sum of each of these sets of forces is zero.

When the guide planes are applied, they translate the arithmetical sum of all the circular forces about the fans into vertical straight line forces, actions thrusting downward against the air and reactions thrusting upward against the planes; while the tangential reactions about the fan pivots remain algebraic zero. In other words, in the total mechanism the fans are floating elements.

Since the tangential fan with flat or nearly flat vanes engages the air with an incidence of 90°, it is the most powerful accelerator of air possible to a aerodynamic science. Therefore the vertical turbine-aero propeller here outlined inherits a like superior lifting power.

To convey some idea of how this mechanism would work out in actual practice I append the following tentative specification with calculations for a small flying unit:

In calculating the lift I have employed the hydraulic formula applicable to the Pelton bucket: $P = \frac{2WAV^2}{G}$, translated into aerodynamic quantities, wherein

P = lift of quadrant a.
W = weight of unit volume of air.
A = area of a single vane.
V = peripheral velocity of acceleration.
G = gravity constant = 32.

Frames (wholly internal)	light spurce trusses
Wing vanes and planes	polished sheet duralumin
Lateral dimension	22 feet
Width of planes	8 feet
Height	12 feet
Diameter of fans	10 feet
Length of vane segments (two segments)	2½ feet
Radial width of segments	2 feet
Total area of wing vanes	80 sq. feet
Total area of planes	340 sq. feet
R. P. M.	120
Net weight	400 lbs.
Gross lifting capacity	720 lbs.
H. P. (for stationary or hovering suspension)	42
Engine speed	constant
Rising, falling and poising controls independent of engine speed	
Stability	inherent
Maximum parachuting speed	20 ft. per sec.

Elvyn F. Burrill.

Berkeley, Cal.

PHOTO-MICROGRAPHS OF PHONOGRAPH RECORDS

To the Editor of the Scientific American Monthly:

Reading the *Literary Digest* for July 24, I noted an article in the Science and Invention Columns, reference being made to an article in your publication, Scientific American, by Francis F. Lucas.

In his article on microscopic study of phonograph records (Scientific American Monthly, June, 1920, pp. 518 to 520) Francis F. Lucas claims that no satisfactory results could be obtained by illuminating the record from above. Thinning down the record specimen must really be patient work if it is like preparing geological specimens.

Let me draw your attention to the enclosed photographs which I took quickly and with no difficulty whatsoever, illuminating from above by a method devised by myself more than a year ago. By turning the mirror of the sub-stage of the microscope any kind of illumination can be obtained. I am sending the result of four characteristic illuminations, one with equally diffused light, for detail and little contrast; another from the side almost perfectly horizontal perpendicular to the ridges and grooves; a third in the line of the triangles, and finally from above. Note how differently the specimen appears and how its character may be studied and how clearly the grit stands out. (The record was carefully dusted with a camel-hair brush.)

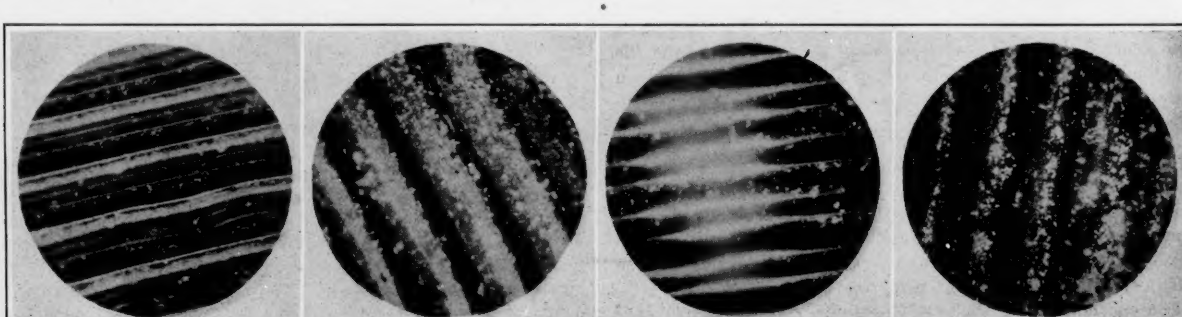
Dayton, Ohio. William A. Beck.

COMETARY ORBITS

To the Editor of the Scientific American Monthly:

A short article by Professor Elis Stromgren, appearing in the June number of the Scientific American Monthly under the caption of "The Origin of Comets," leaves the reader

(*Continued on page 288*)



PHOTOMICROGRAPHS OF PHONOGRAPH RECORDS MADE WITH ILLUMINATION FROM ABOVE—36 DIAMETERS

1. (*Beginning at the left*) Diffused illumination, darker portions are the troughs. Note the grit at bottom and also side of ridge. 2. Same specimen. Illumination along line of troughs; beam almost horizontal, hence ridges not so strongly differentiated. 3. Beam perpendicular to line of troughs. Note how ridges are differentiated and grit shines by reflected light. Beam almost horizontal. 4. Light more inclined, hence grit shines more brightly with consequent halation and less body to the picture. Compare this with the first picture.

(*Continued from page 286*)

somewhat puzzled over the logical process by which is deduced the conclusion that all comets belong to our solar system.

If a mass of matter equivalent to that of a comet were moving in space say half-way between our sun and the nearest fixed star, its motion would be uniform in speed and in a straight line, because the attractive power of the two suns at such a distance would be infinitesimal and would balance each other. If our sun were fixed in space and the planets non-existent, then, if the motion of the body happened to be straight toward the sun, the pull of the sun would gradually accelerate the motion of the body and it would move in an undeviating straight line and ultimately fall into the mass of the sun. If its orbit were directed to a point outside of the sun, it would cease to be a straight line; it would bend toward the sun at an accelerating rate of curvature. But at the same time its momentum would be increasing with its accelerating speed. It would not fall into the sun, but would describe a curve about it and take its way off into space again. If its initial direction and speed happened to have a certain relation the curve would be a parabola. In every other case it would be a hyperbola.

But the sun is not fixed in space, and it is attended by planets, each with its gravitational welcome to the wanderer. As the sun moves the direction of its gravitational pull changes, causing changes in the body's orbit. Each of the planets, especially the major planets, exercises its influence, strong or weak, accordingly as its orbital position happens to be near or far when the body approaches. The resultant of all these perturbational forces may change the orbits of the body in infinite ways. They may change it into a longer or shorter ellipse, a narrower or wider hyperbola.

Similarly with regard to losing a comet from our system. It is true that such happening is improbable in the case of the short time comets whose orbits lie within that of Jupiter. But the long period comets which may happen some time to get within the mighty pull of a near-by Jupiter or Saturn may conceivably have almost any change impressed upon their orbits, which may be altered into ellipses of greater or less major axis, or into hyperbolas, accordingly as the planet at the time happens to be within or without the orbit of the comet.

All this, of course, is merely theoretical. But it has its bearing upon Professor Stromgren's assertion that the comets are all aboriginal members of our system. He adduces no facts which are akin to proof. Take this assertion, which is italicized in the article:

"If one follows for a sufficient length of time the different comets in their passage towards the exterior one finds that not a single hyperbola remains. The cometary orbits which were hyperbolic in the internal portion of the solar system acquired this hyperbolic form by reason of the perturbations to which they were subjected by the planets."

If, owing to perturbations exercised upon a comet while it is approaching the sun its orbit has become hyperbolic, can any one conceive why such perturbations after it recedes should be exclusively corrective, always bringing it back to an enclosed orbit? Why might they not change its orbit into a different hyperbola? It may be presumptuous to say it in face of such an authority, but he goes unwarrantably far in asserting that not a single hyperbola remains when the path of a receding comet is followed for a sufficient length of time, for the good reason that such has not been done for all the long period comets. To trace backward all the perturbations to which a comet has been subjected for thousands of years in order to prove that it has not been made a prisoner from outer space, or to trace forward for thousands of years the perturbations to which it will be subjected in order to prove that its orbit can never become a hyperbola, is a task beyond the power of present, and probably of any future, analysis. The time and the opportunities of astronomical observation have been too limited to justify dogmatic assertions of the kind.

West Somerville, Mass. ROBERT M. BAILEY.

THE EXPANDING EARTH

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

Your July issue contains an article by Hiram W. Hixon, "Is the Earth Expanding or Contracting?" in which he gives a new volcano theory. He correctly assumes that the matter constantly thrown out by the craters, which did not find room inside the earth's crust any more, points to expansion, not contraction, of the earth's volume—contrary to the belief now ruling among geologists. The millions of cubic miles of trachyte, tuff, basalt, lava, volcanic ashes, all of volcanic origin, thrown out from the interior and deposited on the original granite crust, represent expansion, though not of the earth's mass, yet of its volume. Hixon is also right when stating that the advent of the ocean's water (in the shape of steam), to the white-hot core, cannot of itself bring about sufficient force to raise a lava column up to the crater's mouth and expel it. So he concludes the necessary force must be located below the crust, inside the core; and on this basis he arrives at a theory which is certainly novel—though, unfortunately, not tenable.

He bases his theory on a well-known law, and says: "According to Graham's law of the diffusion of gases in a mixed body of gases, each gas occupies the whole space as if the other gases were absent (really known as *Dalton's* law), and he evidently concludes that if the earth's interior is in a gaseous condition (?), all gases pervading each other, more matter could be crowded into the interior than if it were liquid or solid; also that, if any of the internal gases near the shell become solid, owing to the cooling of the shell, the mutual pervasion comes to an end in that solidifying part of the gases, so an expansion must result, as the separated individual elements occupy more space than when they pervaded each other in the gaseous state; and the gases thus set free, mostly steam, expel lava from below.

As stated, this theory is not tenable, even if the earth's interior really were gaseous. Hixon only stated part of Dalton's law, but overlooked another part, which says that "the total pressure of the mixed gases will be the sum of the pressures of all the individual gases." You cannot, under the same pressure, crowd the volumes of several individual gases into the space of one of them, by simply mixing them. If we imagine two closed vessels, of a cubic foot each, the one filled with hydrogen, the other with air, both vessels connected by means of a pipe, it is true that a thorough mixture of the two gases will gradually set in, but that does not mean that they will occupy only one cubic foot, under atmospheric pressure—they will fill the space of two cubic feet, just as before. Hixon assumes that, under the tremendous pressure of the earth's crust, various internal gases, now mixed, will be crowded into a smaller space than if they were separate, and that, if they are separated by a partial congelation, an expansion of volume must take place—but Dalton's law upsets this theory.

Nor could his further theory stand, that the hot internal gases, thus set free by the congelation, will, by their heat, remelt some of the overlying rock and thus form lava. Nor is it likely that the earth's core is in a gaseous condition. If magma solidifies at 1600° C (or at the highest estimate 1700), all layers below the magma have about the same temperature, for any higher or lower temperatures, anywhere within, would readily be equalized by internal convection currents.

Hixon's view that the expulsion of lava results from some internal force, operative below the crust, is most likely correct; but such a factor, admitted as such by the leaders in geologic science, has not been made public as yet.

Stapleton, N. Y. N. JOHANNSEN.